C-11653
Quarterly Progress Report #3
(October - December 2003)

Land Application of Residuals and Chicken Manure in the Lake Okeechobee Watershed: Phosphorus Considerations

April 21, 2004

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A. SAMPLING EVENTS

The Quarter 3 Progress Report documents the soils data, vegetation data, and ground water physical data (water table depths, temperature, electrical conductivity and pH) collected at the Kirton Ranch project site as part of the study of phosphorus implications of the land application of residuals, manure, and commercial fertilizer. Table 1 shows the ground water physical parameters data collection. Tables 2 and 3 show the dates of soils and vegetation sample collection, respectively. Results from the January 26, 2004 soil samples are not yet available.

Table 1. Dates of ground water physical parameters measurements.

Well type	DWT	Temp	EC	pH
Shallow	03/19/03	06/24/03	03/19/03	03/19/03
	06/24/03	08/19/03	06/24/03	06/24/03
	08/19/03	10/03/03	08/19/03	08/19/03
	10/03/03		10/03/03	10/03/03
	11/10/03			
Deep	03/19/03	06/13/03	03/19/03	03/19/03
	06/13/03	06/27/03	06/13/03	06/13/03
	06/27/03	07/17/03	06/27/03	06/27/03
	07/17/03	08/19/03	07/17/03	07/17/03
	08/19/03	10/20/03	08/19/03	08/19/03
	10/20/03	01/20/04	10/20/03	10/20/03
	11/10/03	02/18/04	01/20/04	01/20/04
	12/22/03	03/23/04	02/18/04	02/18/04
	01/20/04		03/23/04	03/23/04
	02/18/04			
	03/23/04			

Table 2. Dates of soil sample collection.

pH	P	Ca	Mg	K	Fe	Al
06/25/03	06/25/03	06/25/03	06/25/03	06/25/03	06/25/03	06/25/03
01/26/04	01/26/04	01/26/04	01/26/04	01/26/04	01/26/04	01/26/04

Table 3. Dates of grass sample collection.

Forage Yield	P concentration in tissue	Mass of P harvested
07/10/03	07/10/03	07/10/03
10/17/03	10/17/03	10/17/03

B. GROUND WATER / PHYSICAL PARAMETERS

Measurements of depth to the ground water table are presented in Tables 4 and 8. These values are relative measurements using the crest of the well cover as the reference point. The well covers are not positioned at a uniform elevation nor have these elevations been surveyed. The crest elevations ranged from level with the ground surface to 10 cm above the local ground surface. Supplemental depth to the water table data were collected near the A-09 flume station and are presented in Figures 25 - 28. These data are referenced to the top of the 2-inch diameter well casing inside the well cover. Measurements were made at 15-minute intervals using a Geokon vibrating wire pressure transducer placed at the bottom of a 3-meter deep well screened to within 50 cm of the ground surface. The sensor is somewhat erratic at times but nevertheless provides a reasonable trace of water table dynamics. Runoff was generated by the pasture plots whenever the water table rose to within 15 cm (0.5 ft) of the ground surface. This corresponds to the approximate elevation of the runoff measurement flume bottoms. The water table first rose to this depth on July 26, 2003 and then remained near to this level throughout the month from August 6 to September 6. It last reached this runoff threshold on September 28, 2003.

The trend was for Block A ground water table to rise faster and thus generate runoff before Blocks B and C. However, Block C water table tended to continue remain high even after Blocks B and A water tables had receded. As a result, Block C generated runoff for a longer period than the upslope blocks. The exception was plot A-17, which in the early part of the rainy season generated much more runoff than any other plot. This was caused by a blockage in the perimeter boundary condition drainage ditch (outside the berm) that did not allow off-site shallow ground water to be intercepted by the external perimeter ditch. Instead, shallow groundwater from beyond the last plot was able to pass under the berm and enter the plot collection ditch. This continued until the blockage was removed and the external shallow drainage water was properly intercepted by the external perimeter ditch and diverted into the main drainage ditch. This clearly indicates that the presence of the shallow collection ditches does have an effect on the near-surface water table and drains down the flooded soils at a rate faster than would otherwise be the case.

Ground water temperatures in shallow wells are presented in Table 5 and Figures 3 and 4. These data show that Block A tends to maintain a slightly higher water temperature than Block B which in turn was slightly higher than Block C. The maximum difference between blocks never reached a full degree Celsius.

Ground water electrical conductivity (EC) results for the shallow wells are presented in Table 6 and Figures 5 – 12. Statistical analysis using a GLM model shows fertilizer type, WTR alum residual amendment, and date to be significant factors affecting electrical conductivity. Not significant were block and fertilizer application amount (low or high P-Level). As shown in Figure 13, EC tended to be higher during the wetter periods. EC was consistently higher under those plots treated with the WTR-alum amendment. Plots treated with Pompano and chicken manure fertilizer sources were associated with higher EC values than plots treated with Boca residuals, which were slightly higher than plots treated with commercial fertilizer.

The shallow ground water pH results are shown in Table 7 and Figures 14 – 21. Statistical analysis using a GLM model shows fertilizer type, WTR alum residual amendment, date, and block to be significant factors relative to pH. Not significant was the fertilizer application amount (low or high P-Level). As shown in Figure 22, pH tended range from 4.9 to 5.7 with the lower values occurring during the wettest periods. Water pH was slightly higher under those plots treated with the WTR-alum amendment. Plots treated with Pompano and chicken manure fertilizer sources were associated with higher pH values compared to plots treated with Boca residuals which, in turn, had slightly higher pH levels than plots treated with commercial fertilizer. A slight block effect on pH is evident with block C having higher values than A which was higher than B. The pH values also tended to be lower during the wettest periods of the year.

Measurements of depth to the ground water table in the deeper wells are presented in Table 8 and Figures 23 and 24. These data show that Blocks A and B consistently had a water table 5 to 10 cm nearer to the surface as compared to Block C. Ground water temperatures measured in the deeper wells are presented in Table 9 and Figures 29 and 30. These data show no correlation with block or any other treatment factor.

Ground water electrical conductivity (EC) results for the deeper wells are presented in Table 10 and Figures 31 – 38. Statistical analysis using a GLM model shows WTR alum residual amendment, block and date to be significant factors affecting electrical conductivity. Not significant were fertilizer type and fertilizer application amount (low or high P-Level). As shown in Figure 36, EC tended to be higher during the wetter periods. EC was consistently higher under those plots treated with the WTR-alum amendment. Block A plots had EC levels lower than either Blocks B or C.

The deeper ground water pH results are shown in Table 11 and Figures 40 – 47. Statistical analysis using a GLM model shows fertilizer type, WTR alum residual amendment, date, and block to be significant factors relative to pH. Not significant was the fertilizer application amount (low or high P-Level). As shown in Figure 48, pH decreased from the dry season into the wet season. Block C plots exhibited lower pH than did Block B, which was still higher than Block C. Water pH was slightly higher under those plots treated with the WTR-alum amendment. The statistics assert a fertilizer type effect, but a clear pattern is hard to detect by inspections of the graphs, even though the Pompano plots do appear to have slightly higher pH values while chicken manure and commercial fertilizer have the lowest.

Shallow Wells Physical Parameters: Depth to Water Table (DWT)

Table 4. Depth to Water Table (cm) as measured in shallow water wells between March 19, 2003 and November 10, 2003.

WELL ID	03/19/03	06/24/03	08/19/03	10/03/03	11/10/03
A1	53.3	43.2	39.4	30.5	85.3
A2	53.3	43.3	35.6	30.5	66.4
A3	54.6	40.8	39.4	30.5	68.0
A4	52.1	43.3	35.6	30.5	63.4
A5	54.6	48.3	38.1	30.6	68.6
A6	57.2	48.3	35.6	30.5	69.5
A7	55.9	48.3	38.7	30.5	68.3
A8	53.3	43.3	31.1	27.9	63.7
A9	53.3	40.8	36.8	27.9	64.3
A10	55.9	43.3	34.9	27.9	63.7
A11	55.9	45.8	30.5	30.6	66.8
A12	49.5	38.1	33.7	27.9	61.6
A13	50.8	43.3	33.7	25.4	62.8
A14	58.4	43.2	27.9	27.9	64.9
A15	53.3	43.2	33.7	30.5	68.6
A16	55.9	43.3	38.1	30.5	69.5
A17	52.6	38.1	33.7	27.9	68.3
B1	49.5	33.0	39.4	30.8	66.1
B2	50.8	30.6	31.8	30.5	63.4
B3	53.3	33.0	35.6	30.7	71.9
B4	52.1	22.9	27.9	31.8	61.3
B5	49.5	22.9	33.0	30.6	63.1
B6	49.5	30.5	33.0	30.5	64.0
B7	54.6	38.2	41.9	31.6	70.4
B8	61.0	40.8	45.1	31.7	70.4
B9	57.2	40.8	33.0	30.6	70.4
B10	55.9	38.2	41.9	30.6	68.9
B11	66.0	48.4	53.3	32.6	75.6
B12	55.9	48.4	47.6	31.8	71.6
B13	64.1	53.5	50.8	30.7	73.5
B14	61.6	53.5	39.4	30.5	65.8
B15	67.3	53.5	48.3	32.0	74.7
B16	68.1	50.9	45.7	32.3	77.1
B17	68.3	53.3	39.4	30.7	76.2
C1	48.3	25.4	38.1	27.9	61.3
C2	45.7	20.3	38.1	24.9	56.4
C3	49.5	20.3	33.7	30.5	59.1
C4	49.5	27.9	50.8	30.5	62.5
C5	50.8	33.0	39.4	38.2	63.7
C6	59.7	38.1	27.9	30.6	67.1
C7	52.1	35.6	41.9	35.7	64.3
C8	49.5	35.7	36.8	36.2	62.8
C9	55.9	40.8	45.1	43.2	68.0
C10	55.9	38.1	47.0	38.1	65.5
C11	50.3	35.6	34.9	35.6	62.5
C12	53.3	38.1	45.1	40.8	66.4
C13	53.3	33.0	36.8	35.6	62.2
C14	55.9	33.0	34.3	34.9	61.9
C15	48.5	27.9	38.1	30.5	56.1
C16	58.4	35.6	33.0	35.6	64.9
C17	57.2	35.6	38.1	35.6	66.1

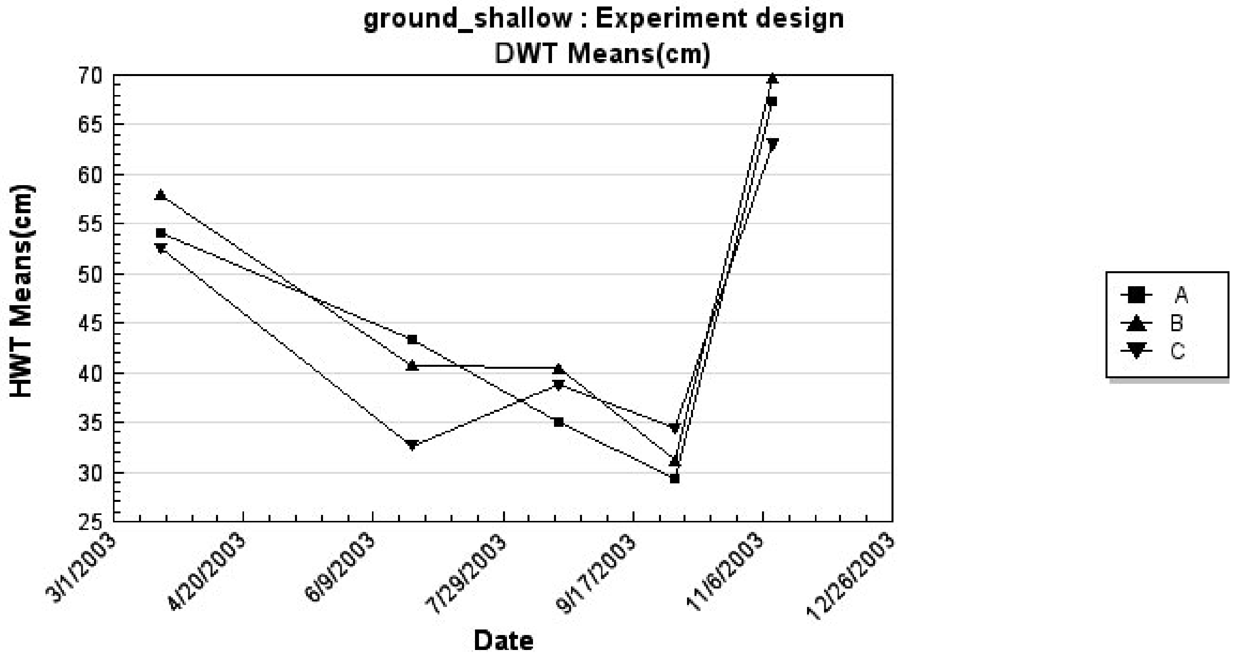

Figure 1. Depth to Water Table (cm) by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

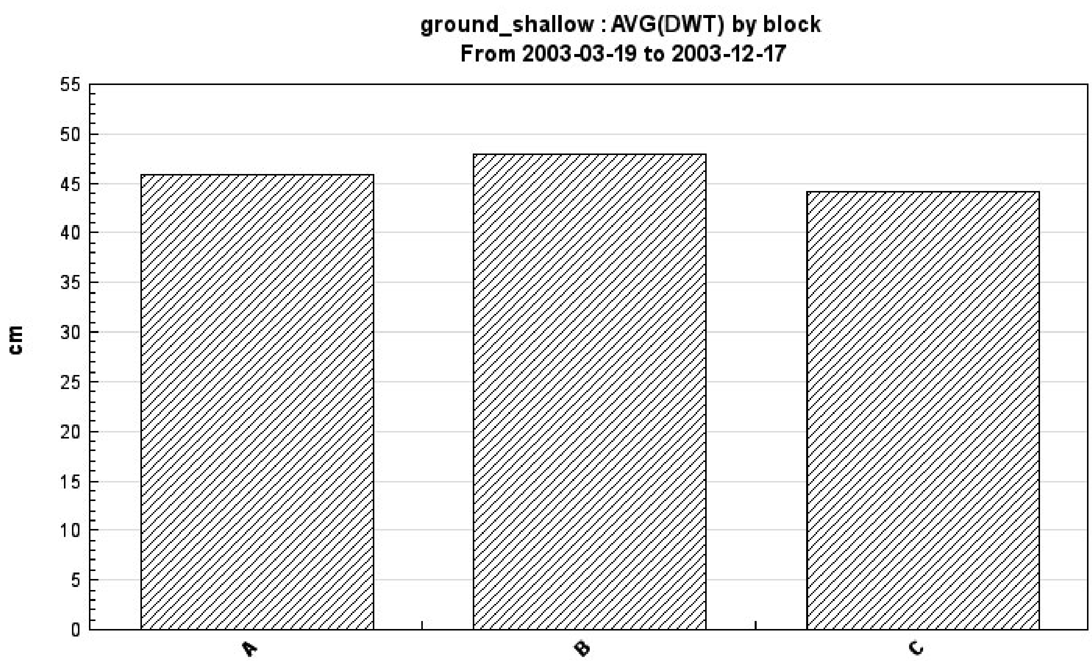

Figure 2. Depth to Water Table (cm) by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

Shallow Wells Physical Parameters: Temperature

Table 5. Temperature (Celsius) as measured in shallow water wells between June 24, 2003 and October 10, 2003.

WELL ID	06/24/03	08/19/03	10/03/03
A1	27.0	28.4	27.0
A2	27.6	28.0	26.7
A3	26.9	28.2	26.8
A4	26.8	27.6	26.5
A5	27.0	27.6	26.6
A6	27.1	26.8	26.6
A7	26.8	27.0	26.7
A8	26.8	26.7	26.6
A9	27.3	26.8	26.3
A10	26.7	26.2	26.0
A11	27.4	27.0	25.9
A12	27.4	26.6	25.7
A13	27.0	26.7	25.8
A14	26.9	26.5	25.6
A15	27.3	27.0	26.2
A16	27.1	26.6	26.0
A17	27.2	26.6	26.0
B1	26.5	26.2	25.7
B2	26.4	26.1	25.8
B3	25.9	26.1	26.2
B4	26.0	26.2	26.4
B5	25.8	26.2	26.4
B6	26.3	26.1	26.4
B7	26.1	26.2	26.4
B8	26.4	26.5	26.8
B9	26.4	26.2	27.0
B10	27.2	26.3	27.4
B11	28.0	26.3	25.8
B12	26.7	26.1	25.6
B13	26.8	26.9	26.0
B14	26.4	26.2	25.6
B15	26.5	26.3	25.8
B16	27.2	26.4	25.8
B17	27.6	26.8	26.0
C1	26.4	26.5	27.3
C2	26.8	26.5	26.9
C3	26.7	26.7	26.6
C4	26.8	26.0	26.1
C5	26.3	26.0	25.9
C6	26.3	25.8	25.8
C7	26.4	25.9	26.0
C8	26.5	26.2	26.0
C9	26.2	25.8	25.9
C10	26.3	26.3	25.9
C11	26.4	26.2	26.0
C12	26.5	26.1	25.6
C13	26.4	26.3	25.6
C14	26.5	26.3	25.4
C15	26.2	26.2	25.5
C16	26.2	26.2	25.4
C17	26.4	26.5	25.7

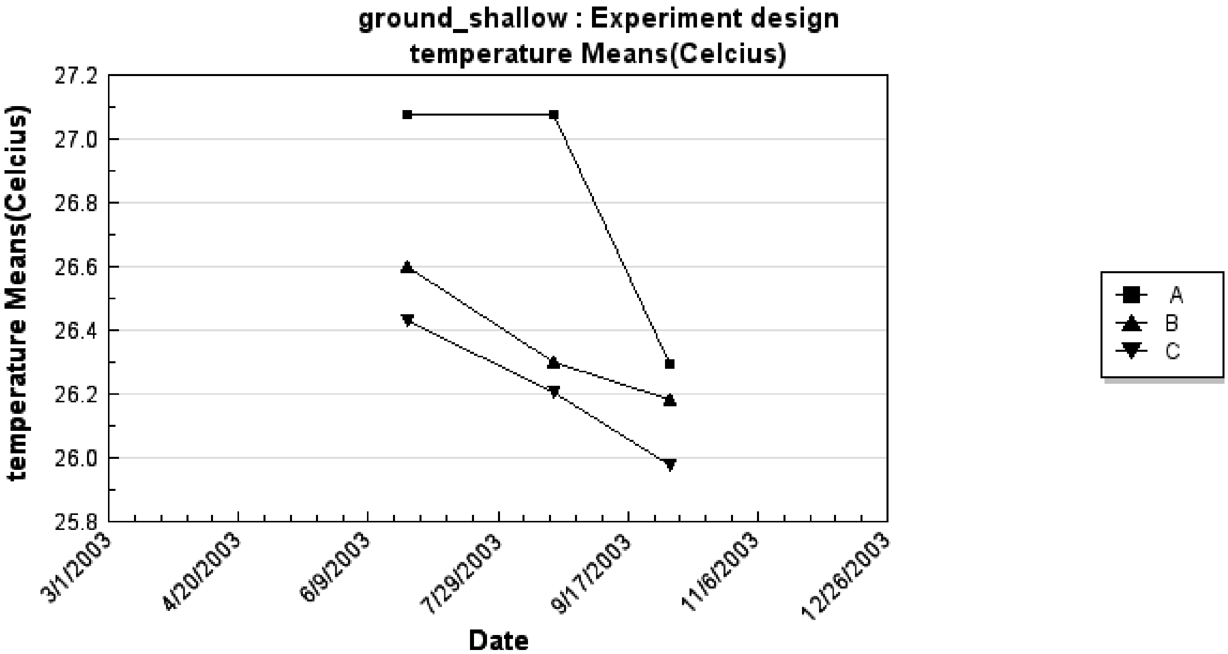

Figure 3. Temperature (Celsius) by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

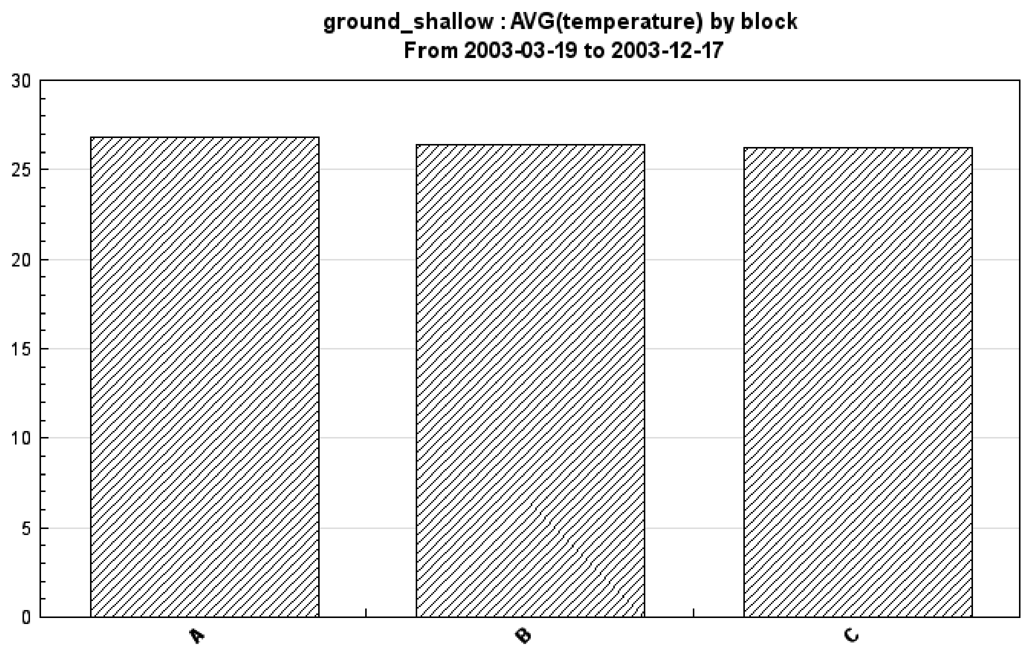

Figure 4. Temperature (Celsius) by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

Shallow Wells Physical Parameters: Electro-conductivity (EC)

Table 6. Electro-conductivity (µS) as measured in shallow water wells between March 19, 2003 and October 10, 2003.

WELL ID	03/19/03	06/24/03	08/19/03	10/03/03
A1	230	302	445	188
A2	173	240	372	182
A3	173	199	201	190
A4	138	207	291	164
A5	138	260	181	182
A6	127	246	214	165
A7	157	440	373	229
A8	126	196	184	176
A9	123	195	224	159
A10	169	181	322	195
A11	100	226	309	207
A12	137	284	284	160
A13	89	207	190	173
A14	64	197	197	160
A15	111	208	163	159
A16	128	195	270	148
A17	116	118	189	147
B1	227	425	459	360
B2	186	536	410	259
B3	165	105	130	108
B4	375	196	264	174
B5	254	223	346	253
B6	182	126	360	276
B7	80	139	195	191
B8	139	164	171	175
B9	127	105	149	157
B10	180	186	253	163
B11	106	98	156	113
B12	103	213	183	153
B13	81	97	147	122
B14	107	141	163	123
B15	122	120	139	127
B16	105	182	157	155
B17	69	118	167	121
C1	206	158	277	197
C2	273	223	177	199
C3	228	276	223	188
C4	131	163	212	199
C5	105	65	184	168
C6	99	210	141	154
C7	99	222	192	148
C8	105	162	143	122
C9	203	374	388	356
C10	355	459	402	483
C11	254	182	201	206
C12	168	181	188	147
C13	244	191	174	151
C14	148	179	205	192
C15	65	169	149	176
C16	133	231	300	267
C17	90	133	102	97

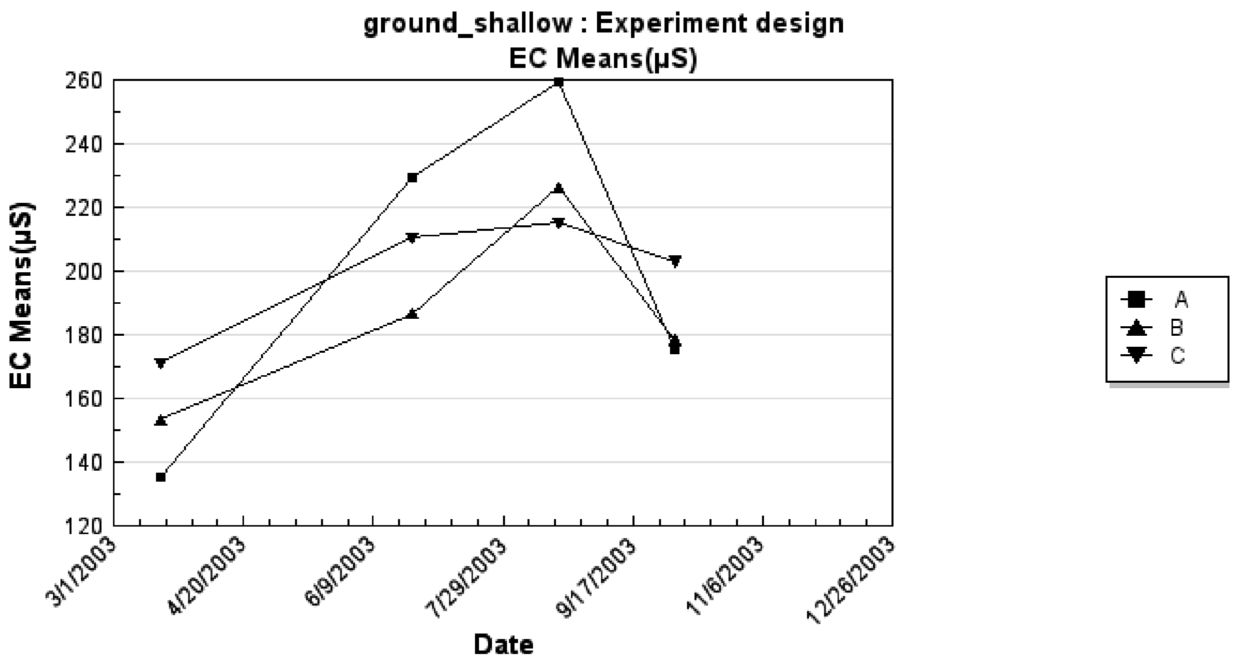

Figure 5. Electro-conductivity (µS) by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

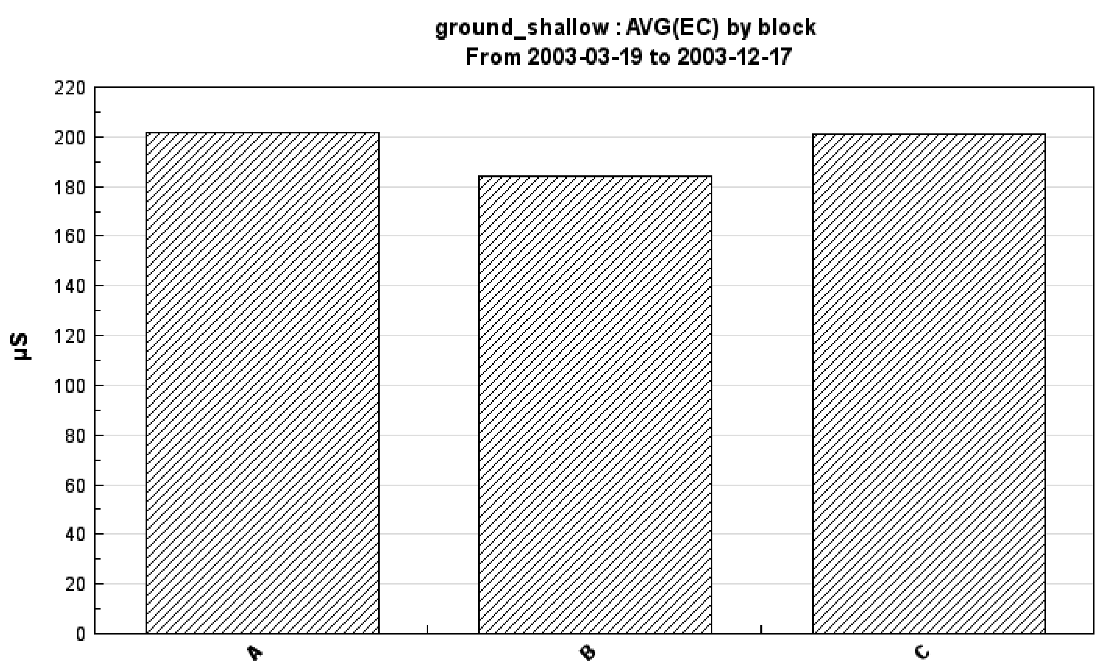

Figure 6. Electro-conductivity (µS) by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

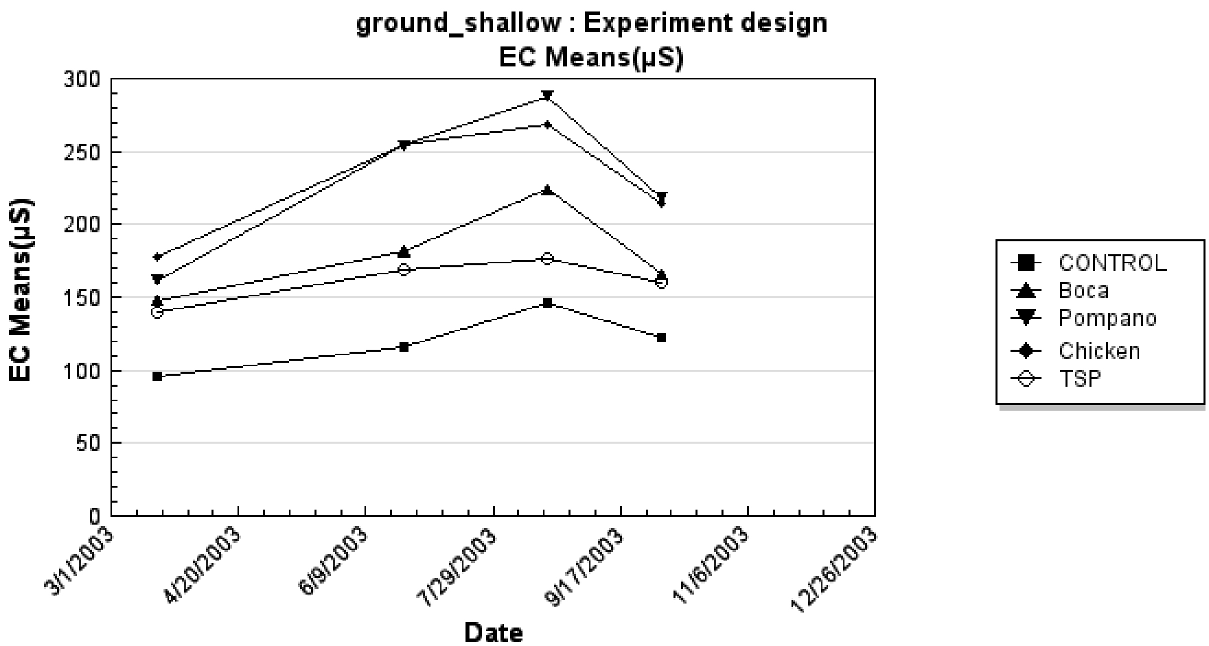

Figure 7. Electro-conductivity (µS) by fertilizer as measured in shallow water wells between March 19, 2003 and December 17, 2003.

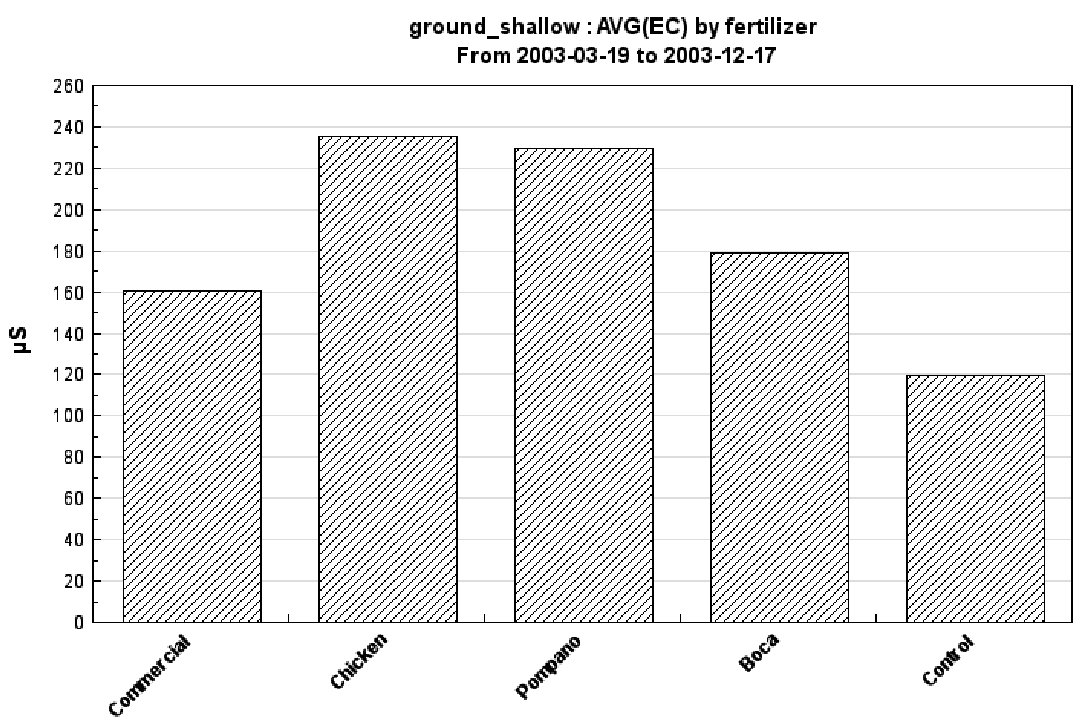

Figure 8. Electro-conductivity (µS) by fertilizer as measured in shallow water wells between March 19, 2003 and December 17, 2003.

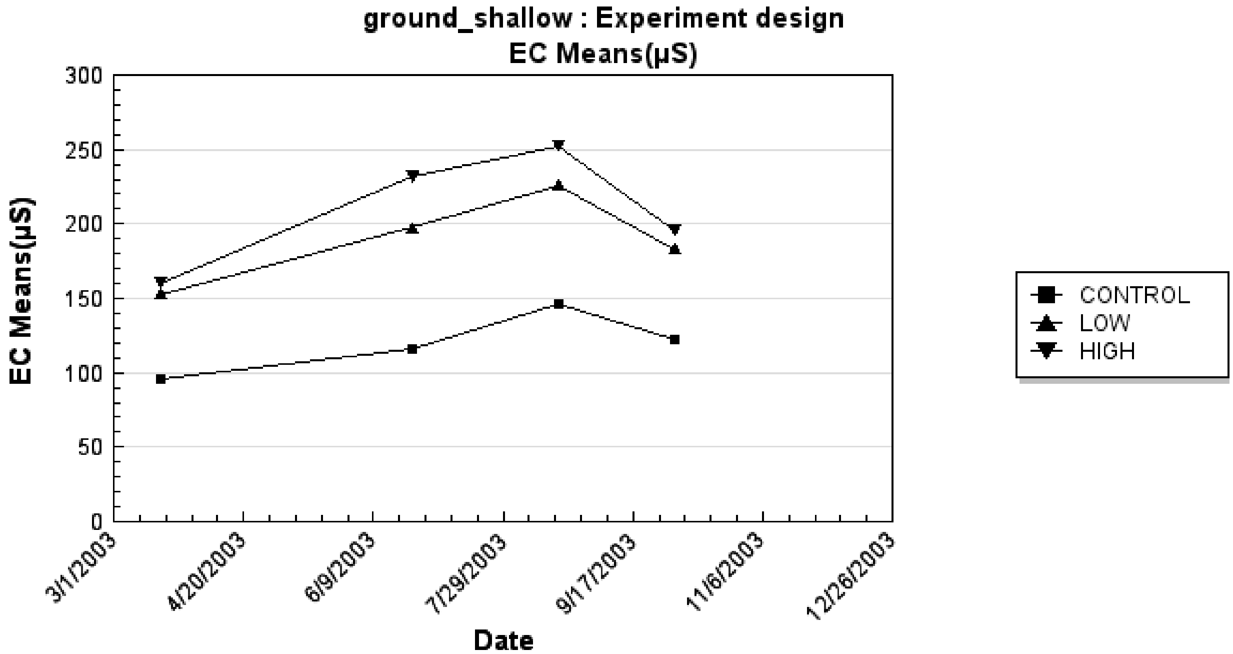

Figure 9. Electro-conductivity (µS) by amount as measured in shallow water wells between March 19, 2003 and December 17, 2003.

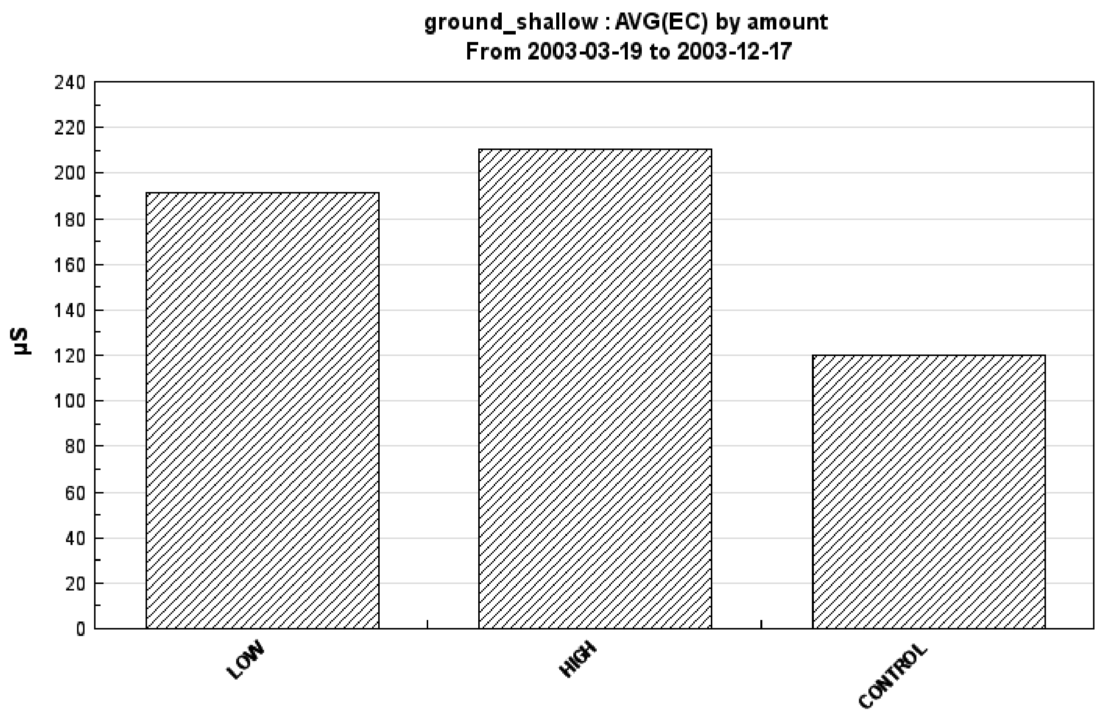

Figure 10. Electro-conductivity (µS) by amount as measured in shallow water wells between March 19, 2003 and December 17, 2003.

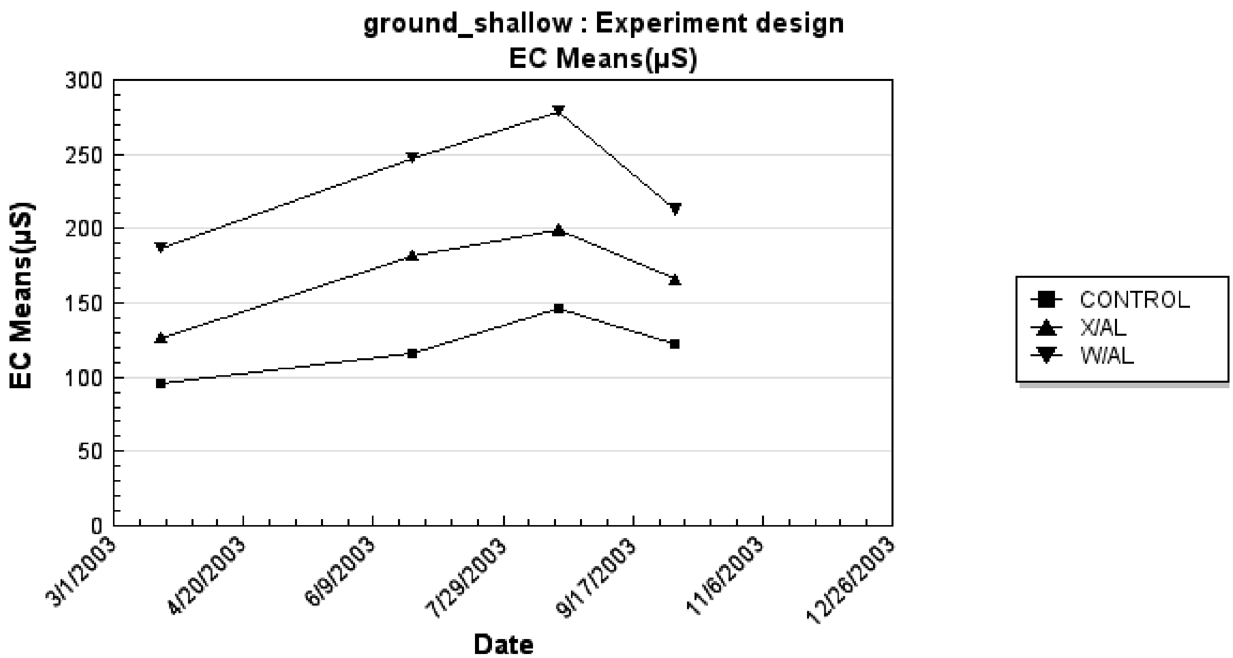

Figure 11. Electro-conductivity (µS) by alum as measured in shallow water wells between March 19, 2003 and December 17, 2003.

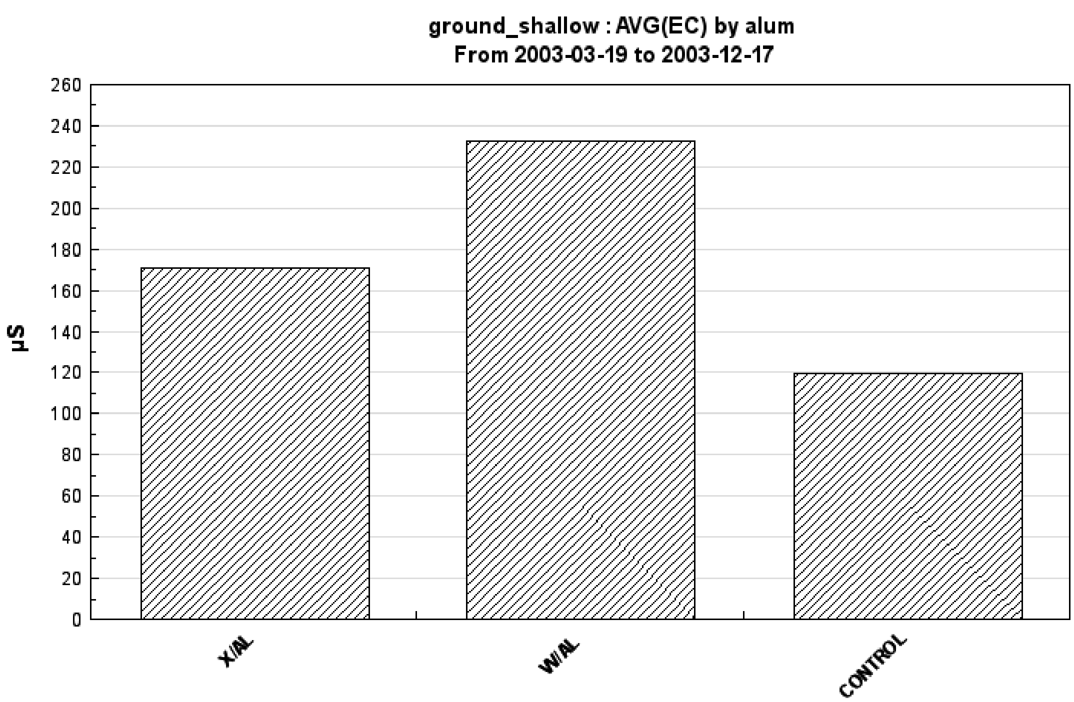

Figure 12. Electro-conductivity (µS) by alum as measured in shallow water wells between March 19, 2003 and December 17, 2003.

Descriptive Statistics: EC_shallow

Variable	N	Mean	Median	TrMean	StDev	SE Mean
EC_shall	192	200.04	182.00	192.63	86.34	6.23

Variable	Minimum	Maximum	Q1	Q3
EC_shall	64.00	536.00	148.00	225.50

General Linear Model: EC_shallow versus Fertilizer, P Level, WTR, Block, Dates

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C
Dates	fixed	4	D_03_19_03 D_06_24_03 D_08_19_03 D_10_03_03

Analysis of Variance for EC_shall, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	175538	177844	59281	12.50	0.000
P Level	1	11312	11312	11312	2.38	0.124
WTR	1	191585	191585	191585	40.39	0.000
Block	2	8281	8281	4141	0.87	0.419
Dates	3	178695	178695	59565	12.56	0.000
Error	181	858543	858543	4743		
Total	191	1423955				

Unusual Observations for EC_shall

Obs	EC_shall	Fit	SE Fit	Residual	St Resid
20	375.000	167.982	16.767	207.018	3.10R
43	254.000	83.143	16.767	170.857	2.56R
55	440.000	272.624	16.495	167.376	2.50R
65	425.000	257.734	16.495	167.266	2.50R
66	536.000	275.443	16.495	260.557	3.90R
70	126.000	259.984	16.495	-133.984	-2.00R
90	459.000	288.131	16.495	170.869	2.56R
97	445.000	294.812	16.495	150.188	2.25R
113	459.000	282.171	16.495	176.829	2.64R
186	483.000	262.985	16.495	220.015	3.29R

R denotes an observation with a large standardized residual.

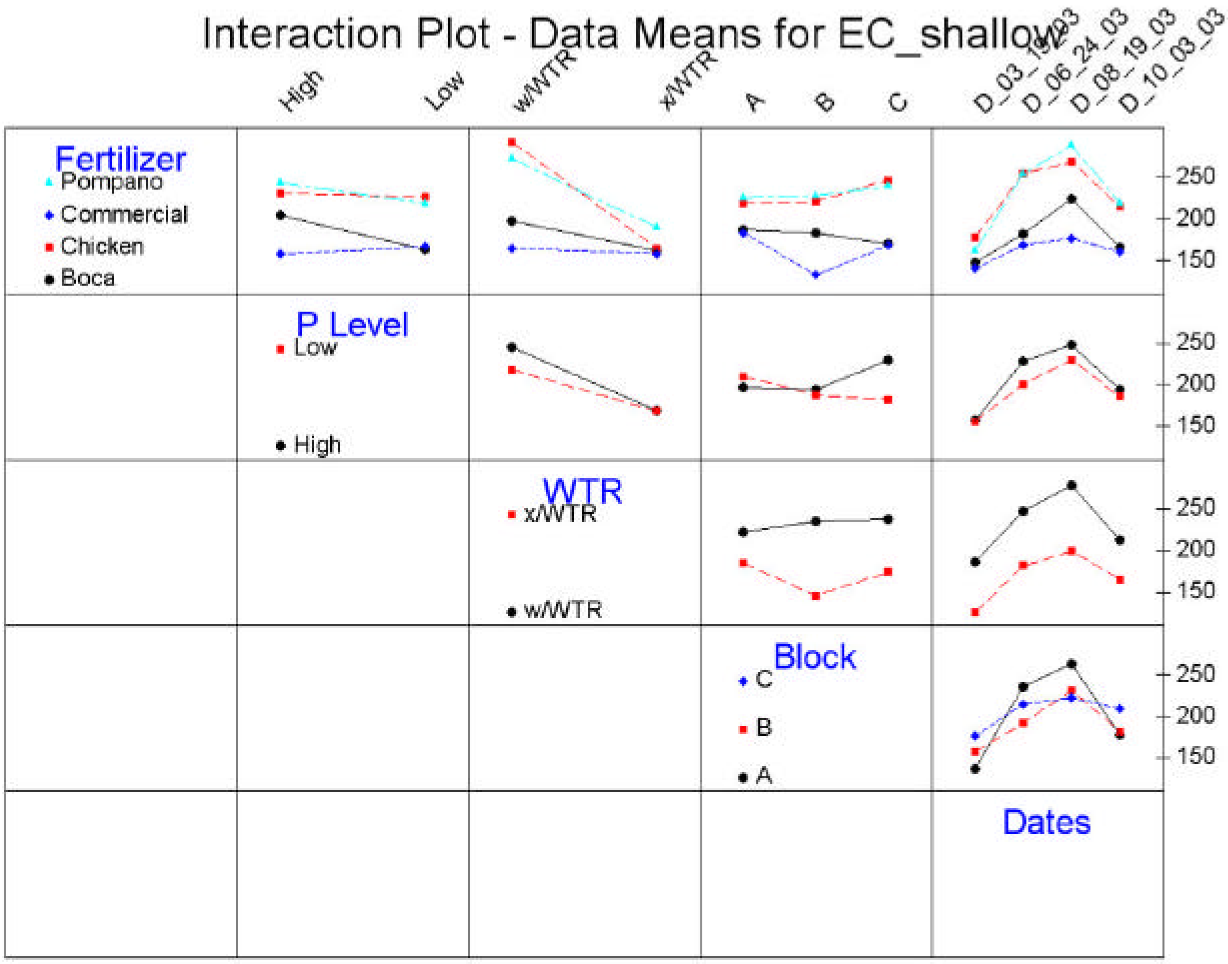

Figure 13. Interaction plot for Electro-conductivity (µS) as measured in shallow water wells between March 19, 2003 and October 3, 2003.

Shallow Wells Physical Parameters: pH

Table 7. pH as measured in shallow water wells between March 19, 2003 and October 3 2003

WELL ID	03/19/03	06/24/03	08/19/03	10/03/03
A1	5.63	4.82	4.15	4.88
A2	6.04	5.34	4.69	5.64
A3	5.47	5.25	4.85	5.44
A4	5.81	5.22	4.68	5.59
A5	6.00	5.67	4.98	5.46
A6	5.08	4.97	4.94	5.30
A7	5.54	5.81	5.26	5.41
A8	5.51	5.44	4.91	5.36
A9	4.82	5.57	5.18	5.16
A10	4.65	4.41	5.27	5.38
A11	4.97	5.27	5.49	5.61
A12	5.37	5.80	5.18	5.44
A13	4.93	5.25	5.11	5.09
A14	5.09	5.41	5.19	5.05
A15	5.23	5.81	5.04	5.14
A16	5.11	5.14	5.20	5.02
A17	4.73	4.85	5.01	4.90
B1	5.84	5.13	4.71	5.90
B2	5.86	5.66	4.80	5.33
B3	5.40	4.96	4.03	4.53
B4	5.95	5.64	5.41	5.73
B5	5.66	5.68	5.53	5.75
B6	5.94	5.52	5.49	5.79
B7	5.53	5.74	5.23	5.52
B8	5.34	5.51	4.89	5.40
B9	5.40	5.09	4.96	5.35
B10	6.01	5.91	5.60	5.70
B11	5.08	5.05	4.87	4.90
B12	5.03	4.69	4.67	5.01
B13	4.57	4.32	5.03	5.01
B14	4.90	4.67	4.72	4.89
B15	5.10	5.08	4.71	4.92
B16	4.46	4.08	4.00	4.24
B17	5.05	5.03	4.96	4.69
C1	5.31	5.31	4.80	5.70
C2	5.43	5.78	5.12	5.52
C3	6.07	6.36	5.29	5.48
C4	5.67	5.74	5.00	5.67
C5	4.84	4.97	4.60	5.43
C6	4.80	4.58	4.48	5.22
C7	5.84	5.31	4.97	4.86
C8	5.75	5.62	4.75	4.94
C9	6.13	5.64	5.90	5.89
C10	6.50	6.55	6.07	6.38
C11	4.44	5.40	4.49	5.47
C12	4.82	4.99	4.96	5.36
C13	5.36	4.96	4.80	5.18
C14	5.31	5.69	5.14	5.20
C15	4.70	5.56	4.85	5.49
C16	5.75	5.72	5.83	6.01
C17	4.64	5.61	4.66	4.80

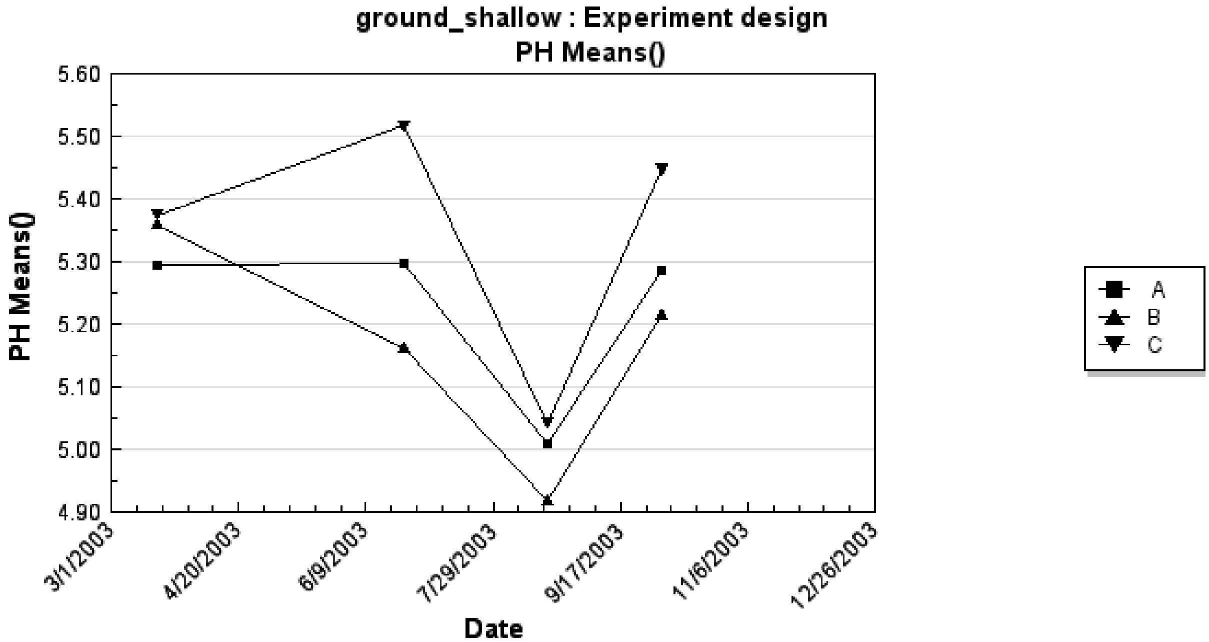

Figure 14. pH by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

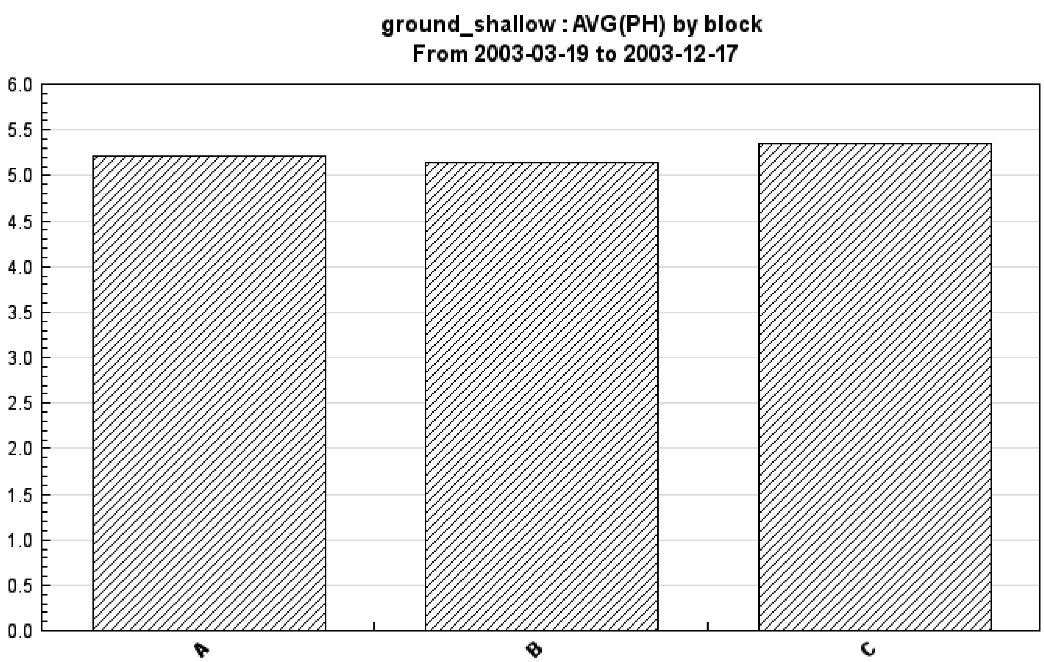

Figure 15. pH by block as measured in shallow water wells between March 19, 2003 and December 17, 2003.

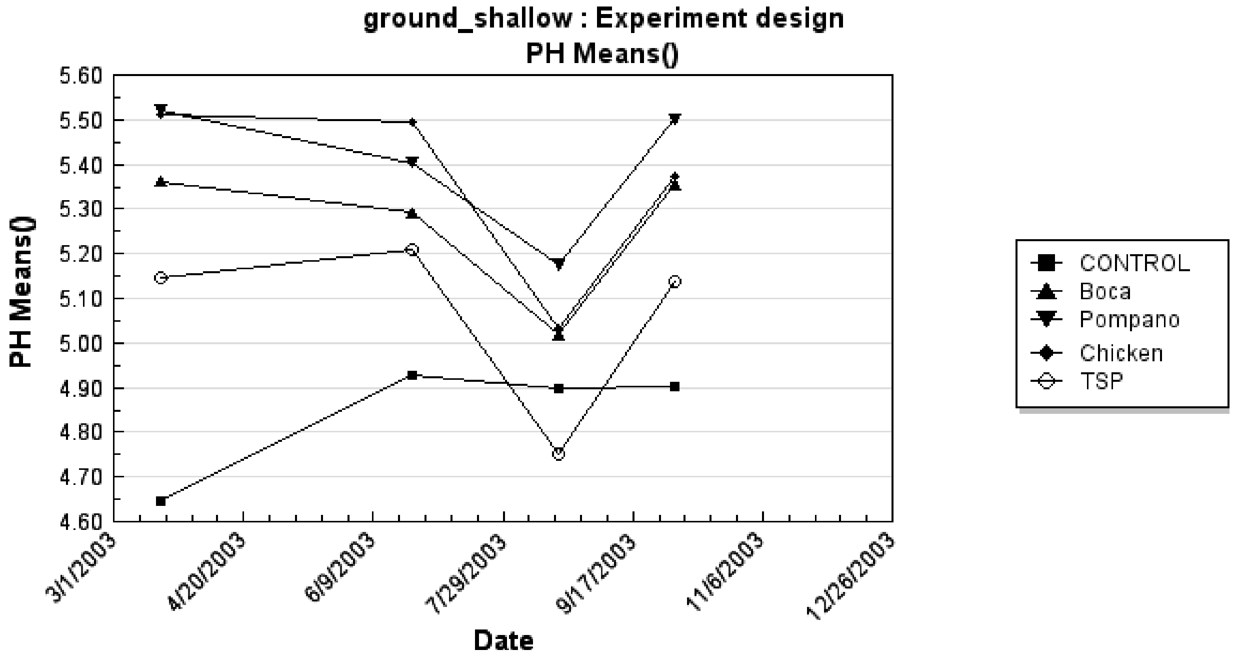

Figure 16. pH by fertilizer as measured in shallow water wells between March 19, 2003 and December 17, 2003.

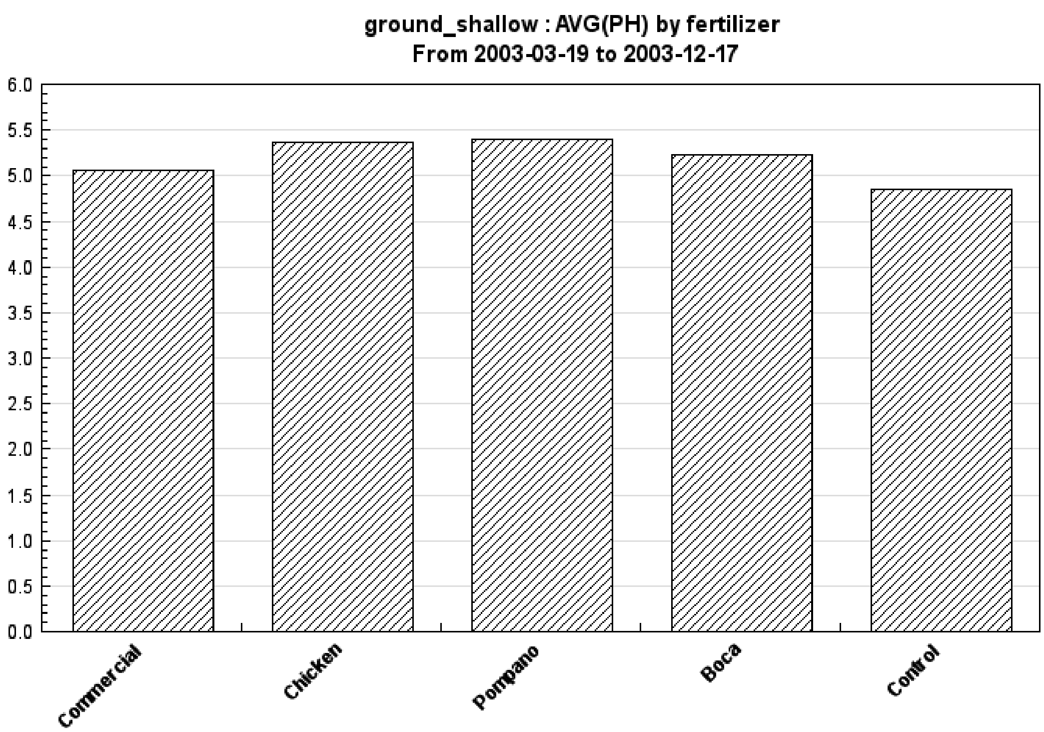

Figure 17. pH by fertilizer as measured in shallow water wells between March 19, 2003 and December 17, 2003.

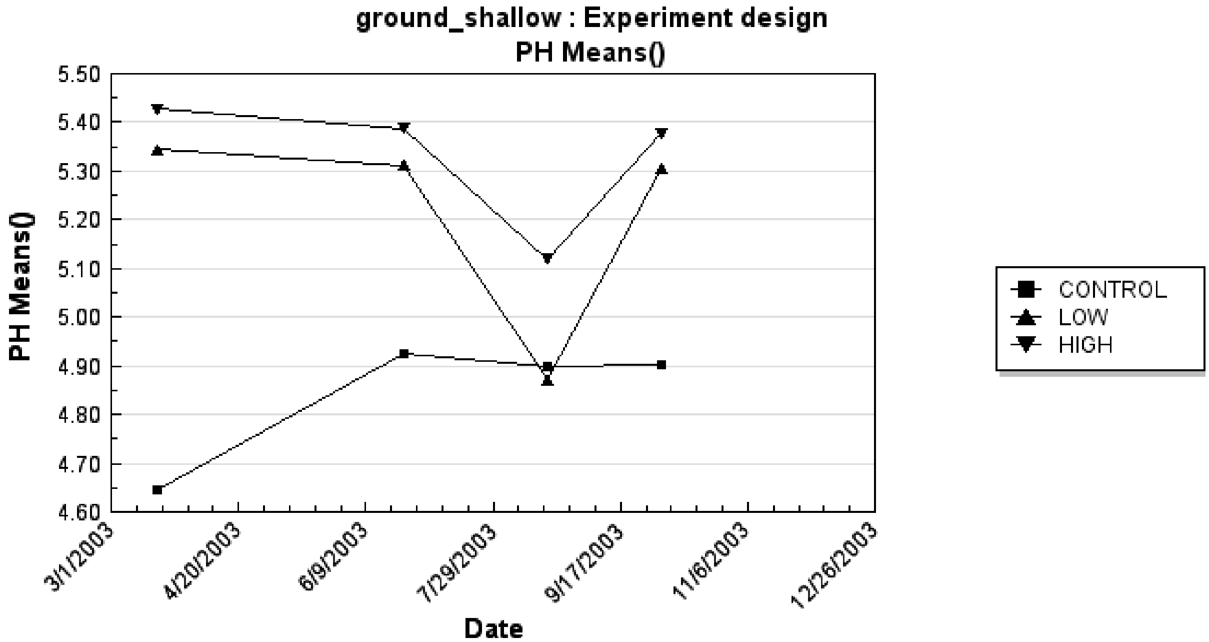

Figure 18. pH by amount as measured in shallow water wells between March 19, 2003 and December 17, 2003.

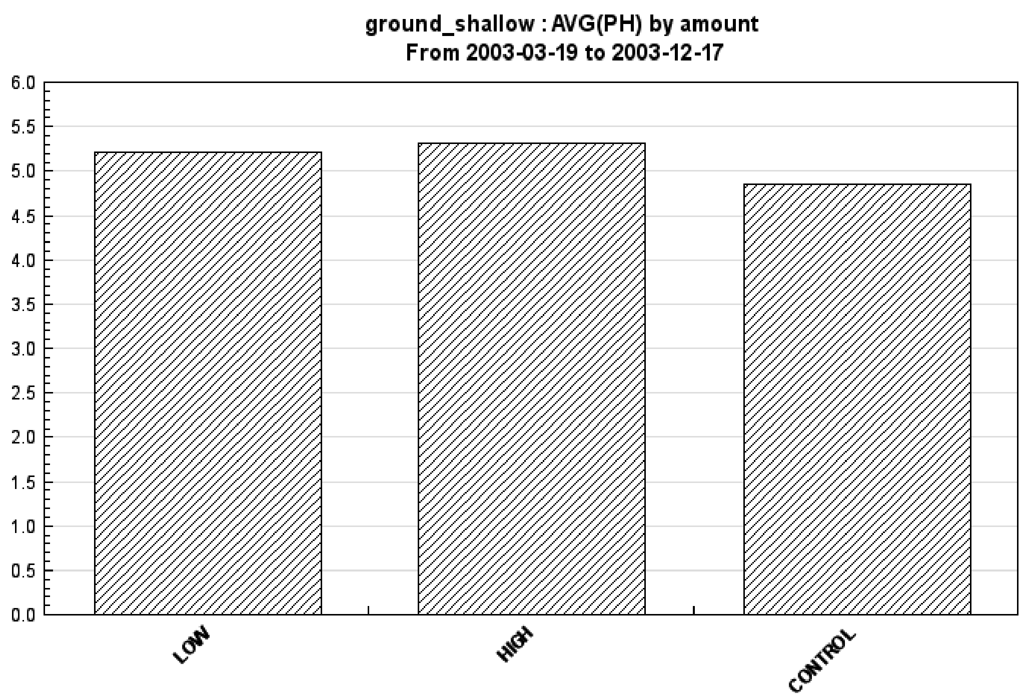

Figure 19. pH by amount as measured in shallow water wells between March 19, 2003 and December 17, 2003.

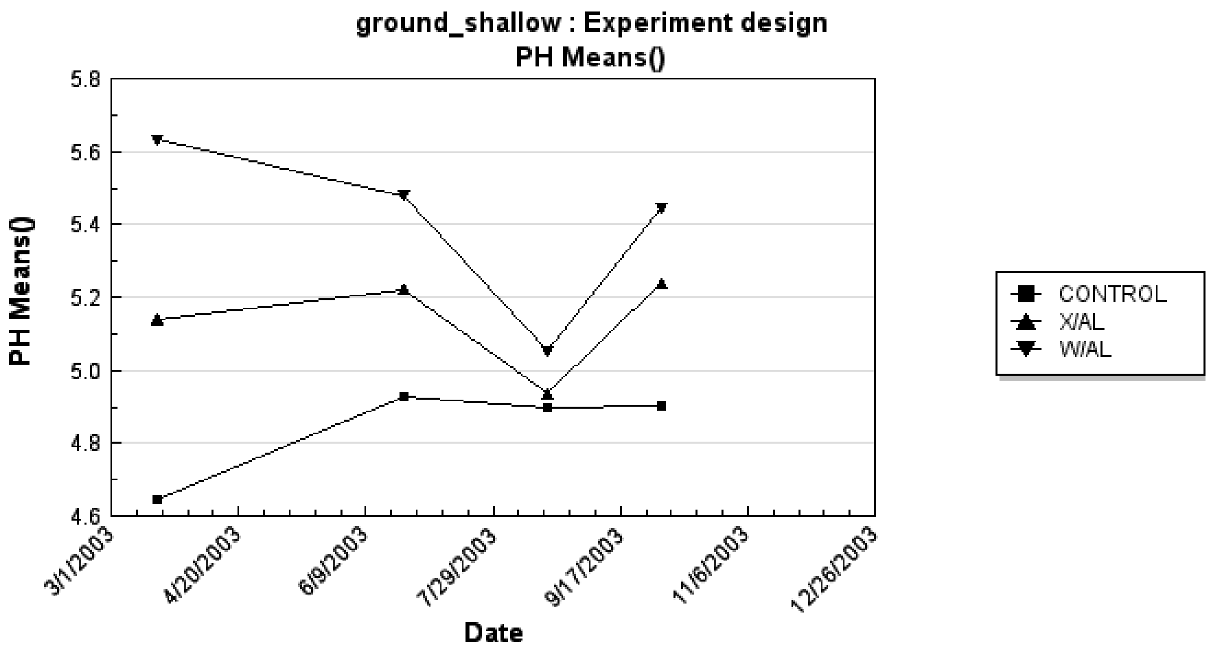

Figure 20. pH by alum as measured in shallow water wells between March 19, 2003 and December 17, 2003.

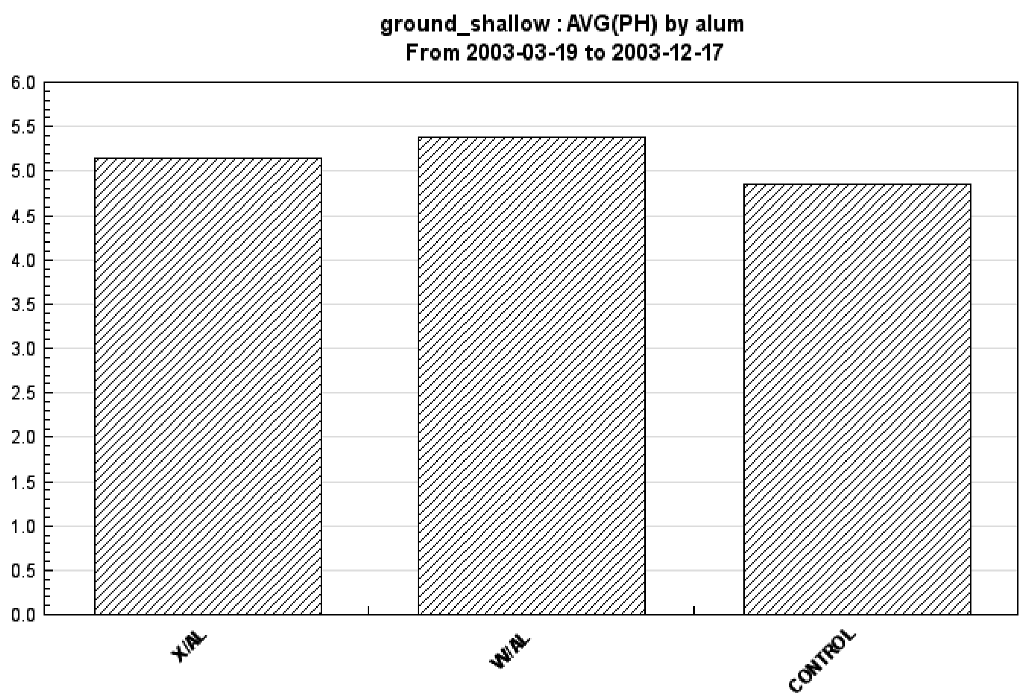

Figure 21. pH by alum as measured in shallow water wells between March 19, 2003 and December 17, 2003.

Descriptive Statistics: pH_shallow

Variable	N	Mean	Median	TrMean	StDev	SE Mean
PH_shall	192	5.2682	5.2700	5.2709	0.4686	0.0338

Variable	Minimum	Maximum	Q1	Q3
PH_shall	4.0000	6.5500	4.9600	5.6175

General Linear Model: pH_shallow versus Fertilizer, P Level, WTR, Block, Dates

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C
Dates	fixed	4	D_03_19_03 D_06_24_03 D_08_19_03 D_10_03_03

Analysis of Variance for pH_shall, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	3.2489	3.3441	1.1147	6.93	0.000
P Level	1	0.2187	0.2187	0.2187	1.36	0.245
WTR	1	3.4427	3.4427	3.4427	21.41	0.000
Block	2	1.1019	1.1019	0.5509	3.43	0.035
Dates	3	4.8355	4.8355	1.6118	10.03	0.000
Error	181	29.0991	29.0991	0.1608		
Total	191	41.9469				

Unusual Observations for PH_shall

Obs	PH_shall	Fit	SE Fit	Residual	St Resid
9	4.82000	5.61341	0.09603	-0.79341	-2.04R
26	6.01000	5.13527	0.09467	0.87473	2.25R
58	4.41000	5.28888	0.09603	-0.87888	-2.26R
63	5.81000	5.01202	0.09467	0.79798	2.05R
74	5.91000	5.09944	0.09467	0.81056	2.08R
79	4.08000	4.96046	0.09467	-0.88046	-2.26R
86	4.58000	5.37039	0.09603	-0.79039	-2.03R
90	6.55000	5.70618	0.09603	0.84382	2.17R
97	4.15000	5.15440	0.09603	-1.00440	-2.58R
122	5.60000	4.74423	0.09467	0.85577	2.20R

R denotes an observation with a large standardized residual.

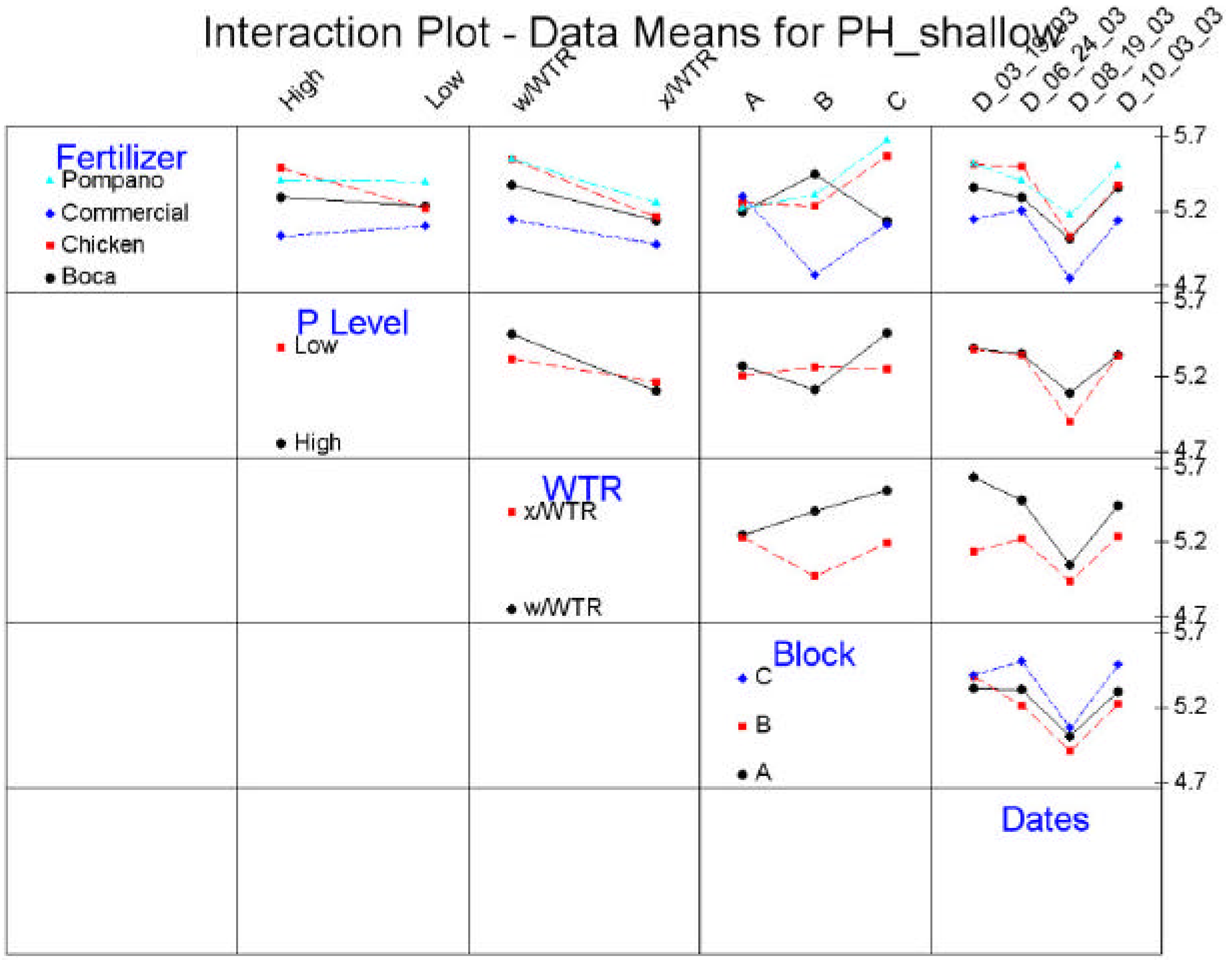

Figure 22. Interaction plot for pH as measured in shallow water wells between March 19, 2003 and October 3, 2003.

Deep Wells Physical Parameters: Depth to Water Table (DWT)

Table 8. Depth to Water Table (cm) as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

ID	03/19/03	06/13/03	06/27/03	07/17/03	08/19/03	10/20/03	11/10/03	12/22/03	01/20/04	02/18/04	03/23/04
A1	50.8	N/A	70.5	91.5	43.2	91.4	68.0	75.3	83.2	105.8	112.8
A2	50.8	91.4	63.5	94.0	39.4	80.0	64.0	69.8	78.0	99.1	106.7
A3	87.6	96.5	73.7	96.5	40.6	94.0	74.1	79.6	91.7	110.9	123.1
A4	87.6	94.0	64.8	94.1	38.1	82.6	67.7	76.8	84.7	104.2	111.3
A5	87.6	96.5	71.7	91.4	45.7	81.3	67.4	74.4	83.8	104.5	109.7
A6	61.0	96.6	64.8	96.5	45.7	91.4	72.5	78.9	88.1	107.0	112.8
A7	61.0	94.1	64.8	89.0	41.9	82.6	72.2	75.6	82.3	103.6	109.7
A8	61.0	91.4	61.0	88.9	36.8	78.7	65.8	71.3	79.6	99.7	105.2
A9	55.9	91.5	61.0	88.9	40.0	80.0	68.9	72.5	79.9	100.6	106.4
A10	72.4	83.9	63.5	91.4	40.6	79.8	68.6	72.8	80.8	101.2	106.7
A11	54.6	91.5	63.5	89.0	38.7	79.5	65.5	72.2	81.1	100.6	105.5
A12	52.1	96.5	63.5	91.5	40.0	80.8	68.6	75.0	83.2	104.5	107.6
A13	52.1	91.4	61.0	88.9	38.1	80.8	66.1	74.4	82.6	103.0	106.7
A14	50.8	94.0	61.0	89.0	39.4	81.3	68.9	76.8	85.6	104.5	108.8
A15	62.2	99.1	62.9	94.0	42.5	83.8	71.0	78.6	89.0	104.9	110.6
A16	59.7	91.5	59.7	88.9	38.1	80.8	67.4	74.4	84.1	103.9	106.7
A17	50.8	83.9	57.8	91.5	36.2	82.6	71.9	77.7	86.6	105.2	109.7
B1	56.4	81.3	N/A	89.0	34.3	81.3	68.3	74.1	84.1	102.1	109.7
B2	57.9	78.8	38.1	83.9	34.3	81.3	62.8	69.2	78.3	99.1	103.6
B3	66.0	81.3	34.3	88.9	36.8	78.2	67.4	71.0	78.6	100.6	107.6
B4	49.5	76.3	33.0	81.3	38.7	78.2	63.1	67.4	74.1	96.9	103.6
B5	52.1	78.8	36.8	81.3	35.6	79.5	62.8	66.8	75.3	96.9	115.8
B6	63.5	81.3	36.8	83.9	40.6	82.0	64.3	68.9	77.4	99.7	103.6
B7	55.9	91.5	44.5	86.4	45.7	83.8	67.4	73.5	79.9	99.7	106.7
B8	85.1	91.5	49.5	88.9	45.1	82.6	69.2	75.3	84.7	104.2	109.7
B9	54.1	94.0	58.4	86.4	41.3	82.6	67.4	74.4	83.5	101.5	108.2
B10	59.7	94.0	58.4	89.0	43.2	94.0	68.0	73.8	82.6	101.5	107.6
B11	68.6	96.5	67.3	96.5	54.0	95.0	77.4	84.1	92.7	110.9	117.3
B12	62.2	94.0	63.5	91.5	48.9	85.1	71.6	79.2	87.8	106.7	111.6
B13	70.5	96.5	66.0	94.0	54.0	94.0	75.0	82.9	93.6	109.1	114.3
B14	57.2	81.3	64.8	94.0	47.0	91.4	65.8	84.4	93.9	111.3	115.8
B15	62.9	96.5	63.5	94.0	48.3	85.6	71.9	80.5	93.3	108.8	114.3
B16	78.1	96.5	64.8	94.0	48.3	96.5	75.0	83.2	95.1	141.7	115.2
B17	70.5	96.6	64.1	96.5	47.0	85.3	75.9	84.7	93.3	109.7	115.8
C1	50.8	83.8	25.4	81.3	26.0	78.7	61.3	64.6	72.2	92.0	102.1
C2	40.6	73.7	20.3	73.7	21.0	71.1	53.9	56.7	61.9	83.5	112.8
C3	48.3	76.2	19.1	78.8	30.5	75.7	58.8	62.2	68.9	75.6	99.1
C4	53.3	78.8	28.0	83.8	36.8	75.4	62.2	66.4	73.2	94.2	103.6
C5	57.4	83.8	33.0	83.8	40.0	82.3	64.9	68.3	76.8	95.1	100.6
C6	53.3	83.8	35.6	86.4	41.9	82.6	65.5	70.4	77.4	96.9	106.1
C7	70.5	83.9	39.4	88.9	43.2	82.8	66.1	71.0	79.9	99.1	105.8
C8	78.7	91.5	41.9	86.4	45.7	83.8	68.3	72.2	81.1	99.1	107.3
C9	58.4	91.5	40.6	88.9	45.7	65.5	65.2	70.1	78.6	97.8	103.6
C10	58.4	83.9	38.1	86.4	43.8	65.5	65.2	67.7	79.6	95.1	100.6
C11	53.3	94.0	39.2	91.4	45.1	83.8	67.4	72.5	80.5	100.6	109.7
C12	58.4	91.4	36.8	86.4	45.1	81.3	65.2	70.1	76.8	97.5	106.7
C13	61.0	91.5	36.8	88.9	35.6	81.3	65.8	71.3	78.0	99.1	108.2
C14	53.3	83.8	30.5	86.4	36.8	76.7	62.8	66.4	73.8	93.9	102.1
C15	52.1	94.0	35.6	83.8	40.0	78.7	63.7	69.2	77.1	96.0	103.6
C16	52.1	91.5	36.2	86.4	33.0	79.5	65.5	69.8	76.5	97.5	106.7
C17	55.9	94.0	39.4	86.4	40.6	80.0	62.2	71.9	82.9	100.6	106.7

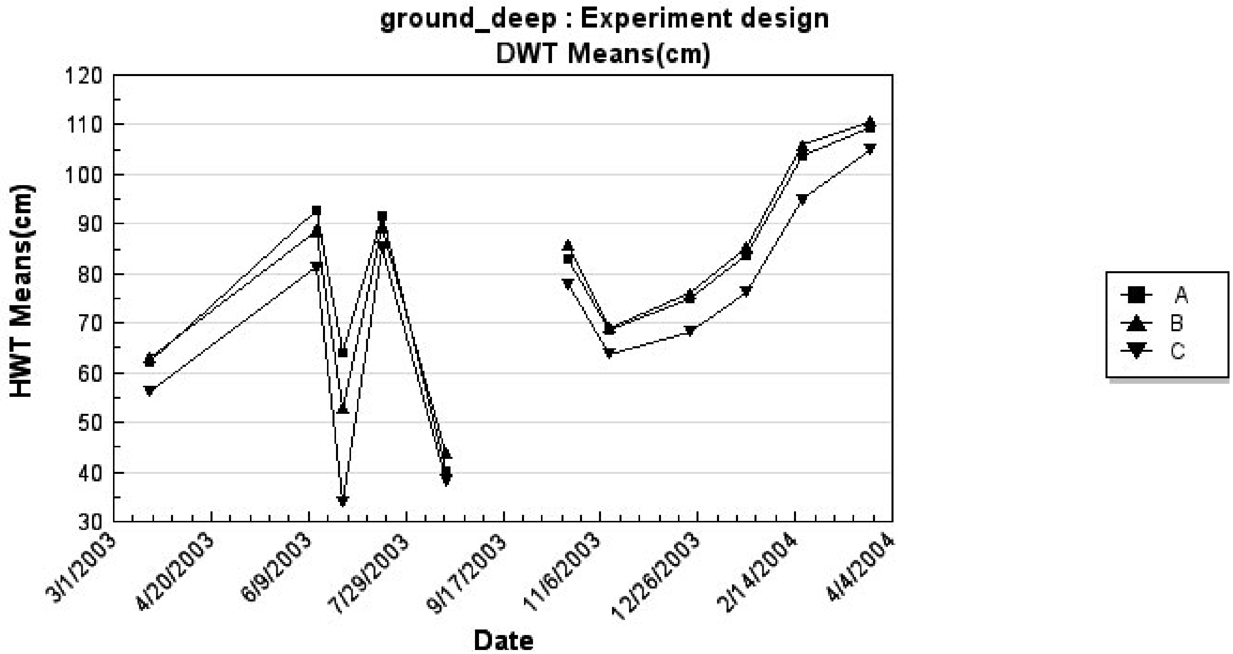

Figure 23. Depth to Water Table (cm) by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

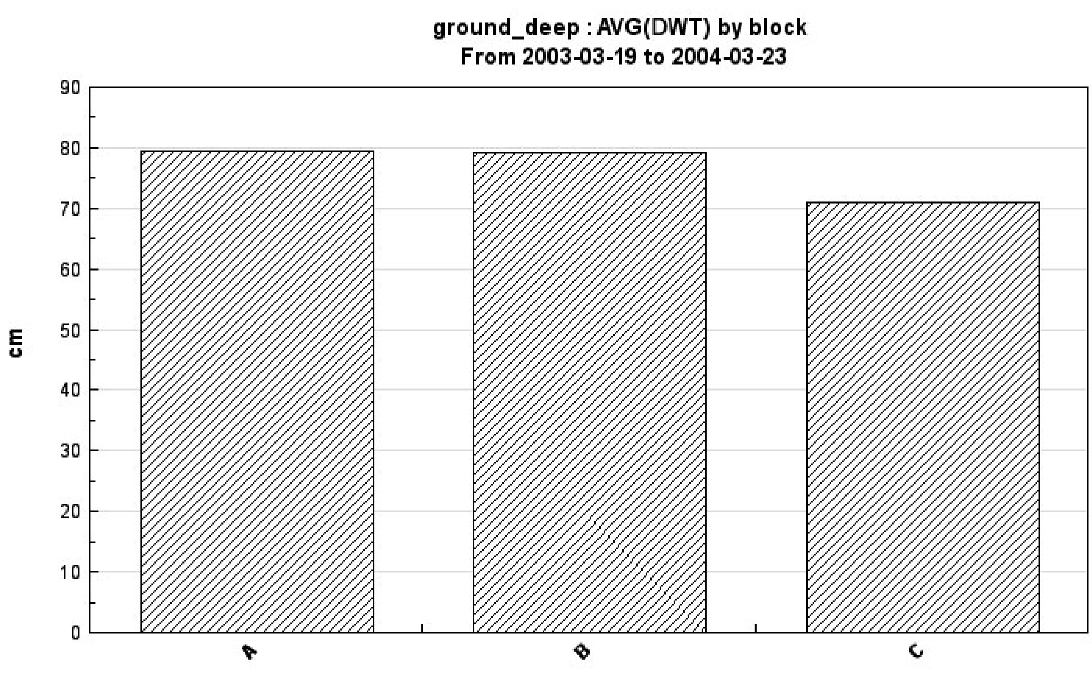

Figure 24. Depth to Water Table (cm) by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

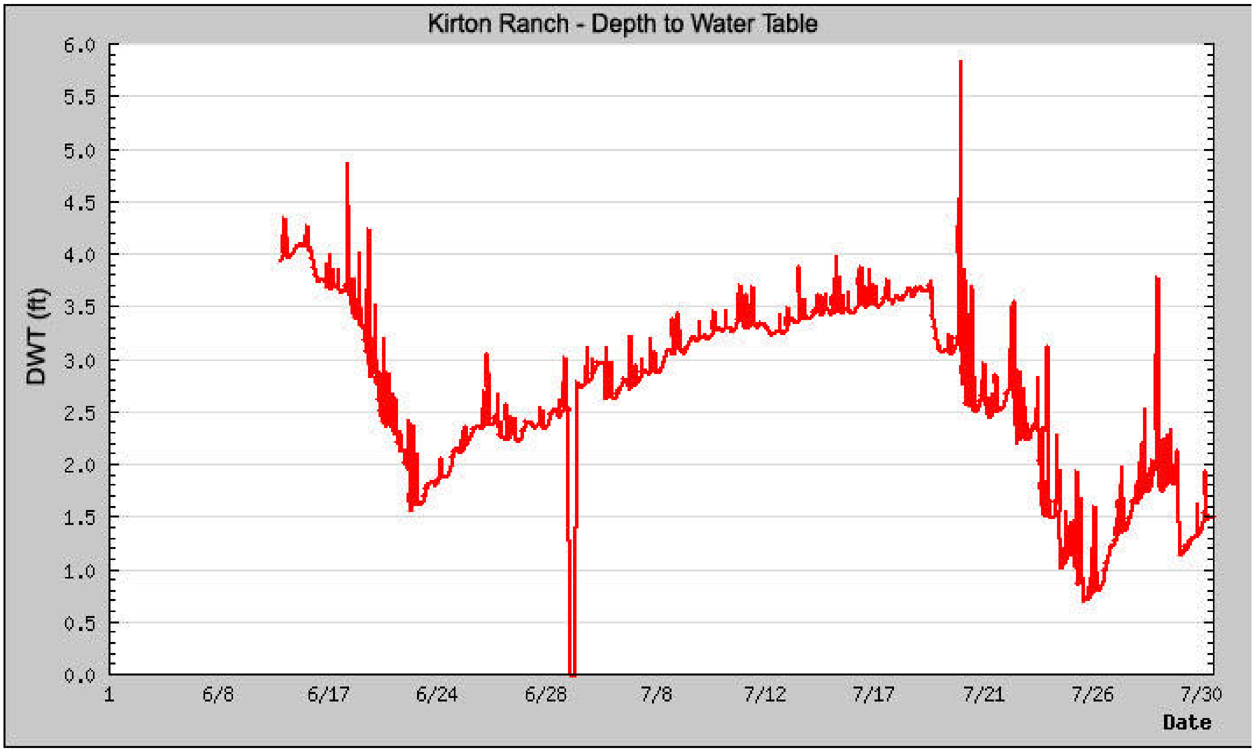

Figure 25. Depth to water table (feet) as measured between June 1, 2003 and July 31, 2003 near the A-09 flume.

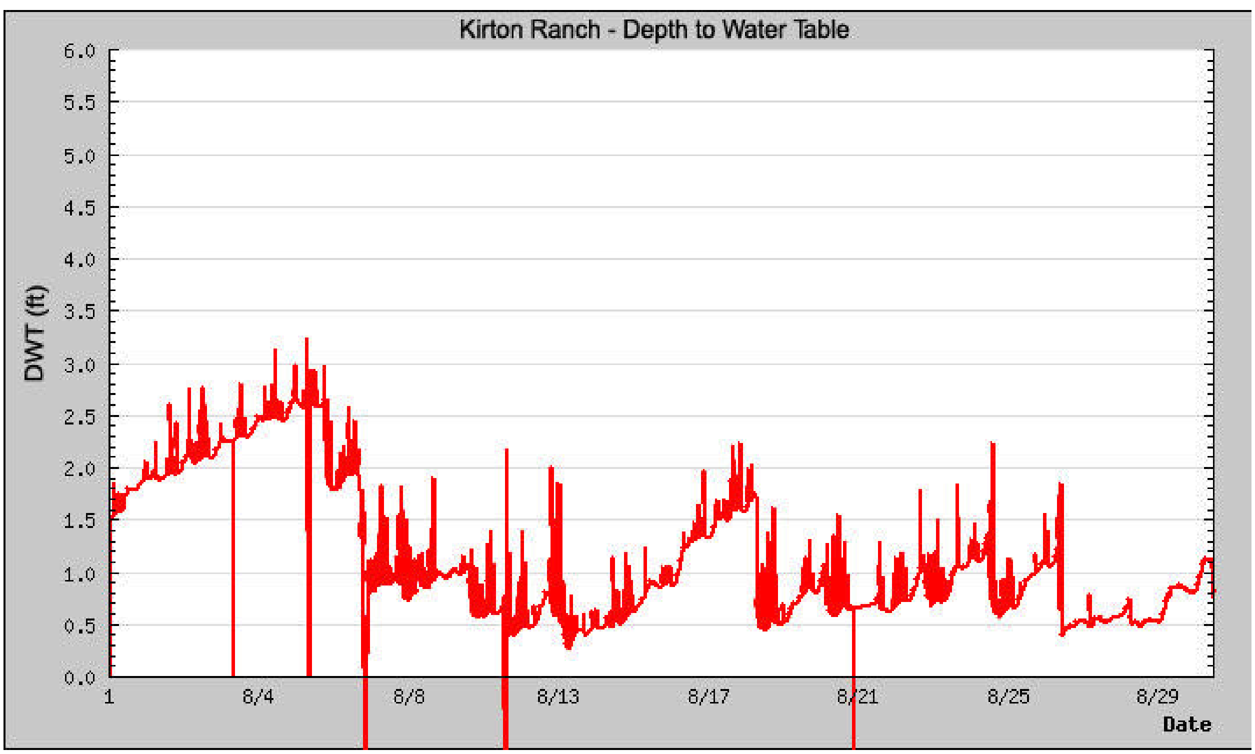

Figure 26. Depth to water table (feet) as measured between August 1, 2003 and August 31, 2003 near the A-09 flume.

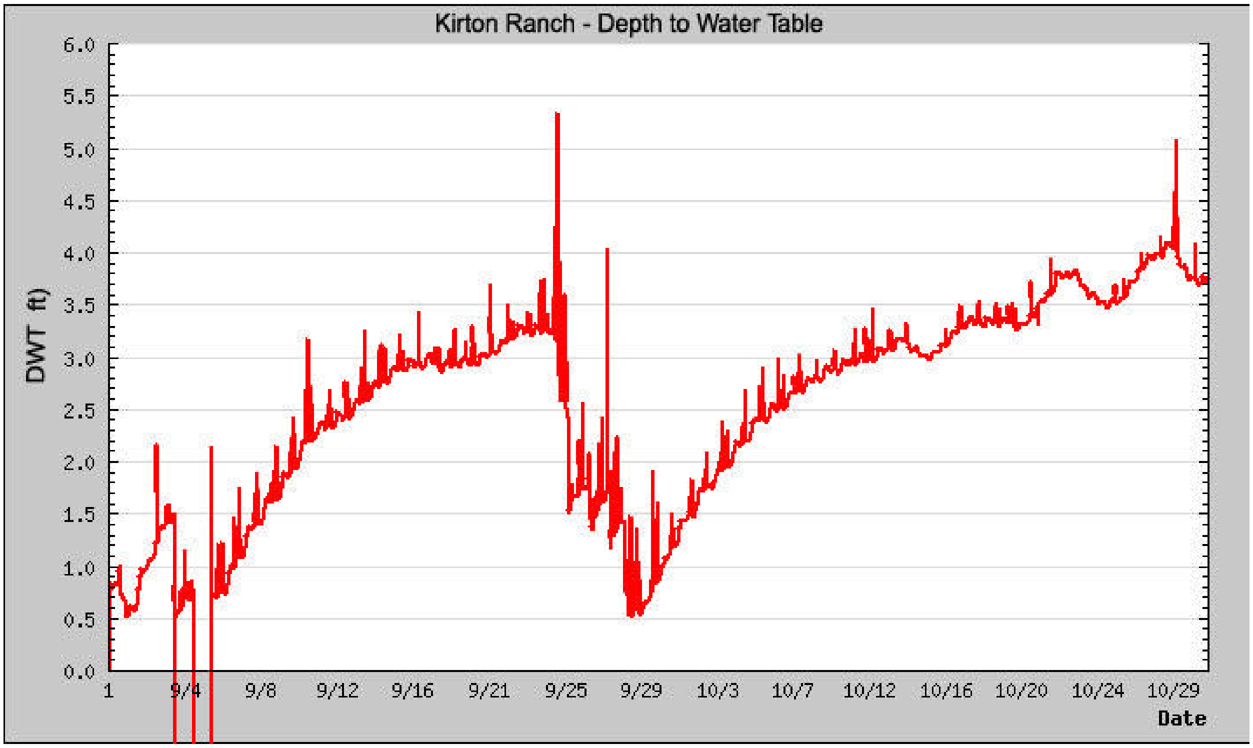

Figure 27. Depth to water table (feet) as measured between September 1, 2003 and October 31, 2003 near the A-09 flume.

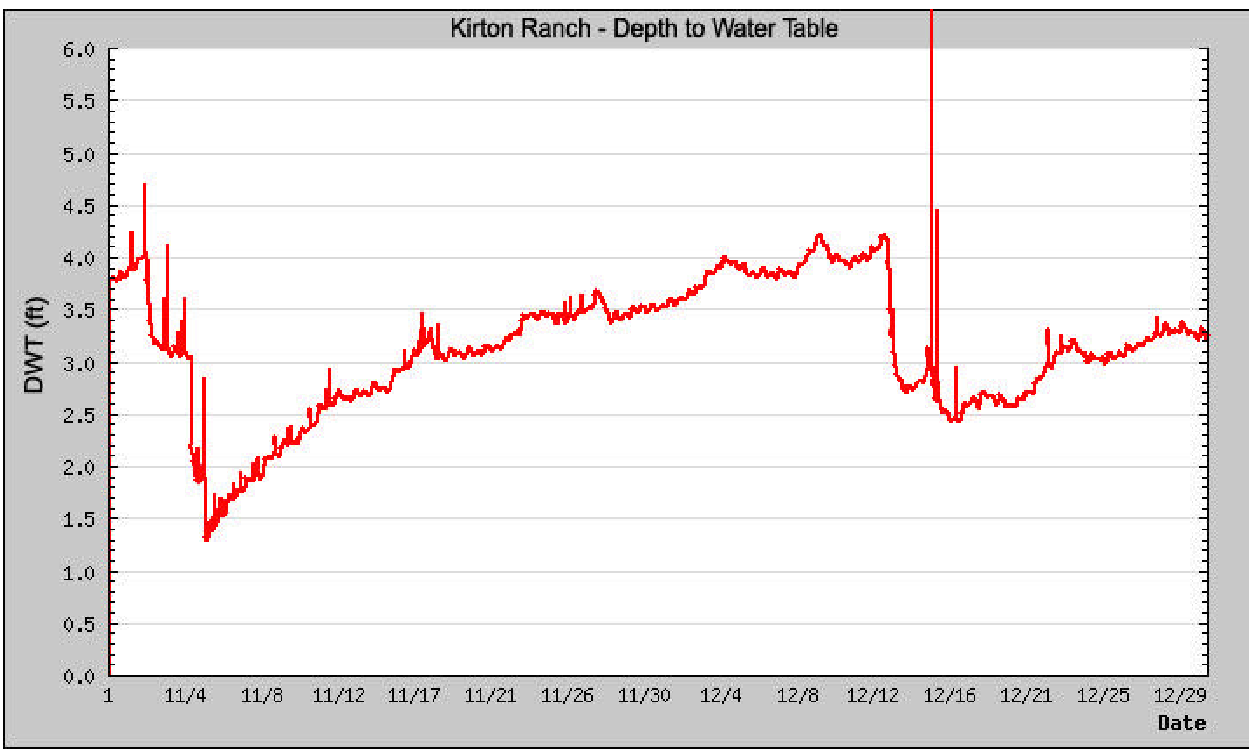

Figure 28. Depth to water table (feet) as measured between November 1, 2003 and December 31, 2003 near the A-09 flume.

Deep Wells Physical Parameters: Temperature

Table 9. Temperature (Celsius) as measured in deep ground water wells between June 13, 2003 and March 23, 2004

ID	06/13/03	06/27/03	07/17/03	08/19/03	10/20/03	01/20/04	02/18/04	03/23/04
A1	26.6	27.8	27.3	29.0	25.8	19.7	19.4	20.7
A2	26.9	27.3	26.9	28.2	25.4	19.5	19.4	20.7
A3	26.2	26.7	26.8	28.0	25.2	19.3	19.0	20.6
A4	25.6	27.2	26.4	28.1	25.4	20.9	19.4	20.4
A5	25.8	27.0	26.5	27.6	25.1	21.0	19.4	20.6
A6	26.8	27.2	26.3	27.0	25.2	20.3	19.5	20.3
A7	27.9	27.2	26.8	26.9	25.3	20.1	19.2	20.4
A8	26.7	27.0	26.2	26.8	25.0	18.8	19.0	20.4
A9	26.3	27.3	26.3	26.6	25.0	19.8	19.2	20.4
A10	26.2	26.9	26.3	26.2	25.2	19.3	19.6	20.2
A11	26.3	26.6	26.3	26.7	25.0	19.7	19.2	20.2
A12	26.0	26.6	26.2	26.4	24.8	19.8	19.5	20.0
A13	25.9	26.4	26.3	26.6	24.9	19.9	19.4	20.2
A14	25.6	26.7	26.3	26.2	24.8	19.6	19.6	20.2
A15	25.6	27.0	26.6	26.5	24.9	20.0	19.4	20.2
A16	25.6	27.0	26.3	26.4	24.1	19.5	19.6	20.2
A17	25.1	26.8	26.1	26.6	24.8	19.4	19.6	20.4
B1	25.3	25.6	26.9	26.1	24.2	19.4	19.8	20.0
B2	25.4	25.5	26.2	25.9	24.2	19.4	19.1	19.9
B3	25.6	25.4	26.4	26.0	24.5	19.8	19.6	20.0
B4	25.6	25.5	26.7	26.1	24.3	19.2	19.5	20.0
B5	24.6	25.4	27.0	26.1	24.4	19.3	19.6	20.0
B6	24.8	25.4	26.7	26.1	24.4	19.1	19.5	20.0
B7	25.1	25.7	26.3	26.0	24.3	19.3	19.6	20.0
B8	25.2	25.9	25.9	26.5	24.5	19.1	19.6	20.0
B9	24.7	25.2	26.4	26.0	24.6	19.5	19.9	20.2
B10	25.0	25.4	26.7	26.1	24.9	19.3	19.4	20.4
B11	24.7	25.5	26.7	26.1	24.2	19.4	19.7	20.2
B12	25.3	25.6	26.2	26.0	24.3	19.3	19.5	20.0
B13	25.4	25.8	26.0	26.4	24.5	19.3	19.6	20.2
B14	25.6	25.4	26.0	26.1	24.1	19.3	19.8	20.1
B15	26.0	25.2	26.7	26.1	24.3	19.5	19.7	20.1
B16	25.9	25.7	26.0	26.1	24.3	19.4	20.0	20.3
B17	26.3	26.0	26.1	26.6	24.5	19.4	19.9	20.6
C1	27.0	25.7	27.1	26.8	23.9	19.4	19.9	20.2
C2	26.4	25.2	26.6	26.6	24.2	19.6	19.6	20.1
C3	25.7	25.4	26.4	26.4	24.4	19.5	19.6	20.1
C4	25.2	25.2	26.0	26.3	24.1	18.8	19.2	19.8
C5	25.6	25.2	25.9	26.2	24.0	19.6	19.5	19.8
C6	25.7	25.4	26.2	25.9	24.3	19.7	19.4	19.8
C7	23.6	25.4	26.4	25.7	24.2	19.9	19.8	19.8
C8	24.4	25.2	26.2	26.0	24.4	19.7	19.4	19.9
C9	25.0	25.6	26.8	26.2	24.2	19.2	19.6	19.8
C10	25.0	25.7	27.6	26.4	27.2	19.0	19.8	20.0
C11	N/A	25.2	25.9	26.2	25.9	19.4	19.6	20.3
C12	N/A	25.3	26.0	26.5	25.4	19.2	19.5	20.0
C13	N/A	25.1	25.9	26.1	28.4	19.2	19.4	20.0
C14	N/A	25.2	26.6	26.3	26.1	19.1	19.2	20.0
C15	N/A	25.2	27.0	26.5	25.8	19.4	19.4	20.0
C16	N/A	25.5	27.4	26.3	25.7	19.2	19.4	19.8
C17	N/A	26.6	26.9	26.4	27.0	18.8	19.5	20.4

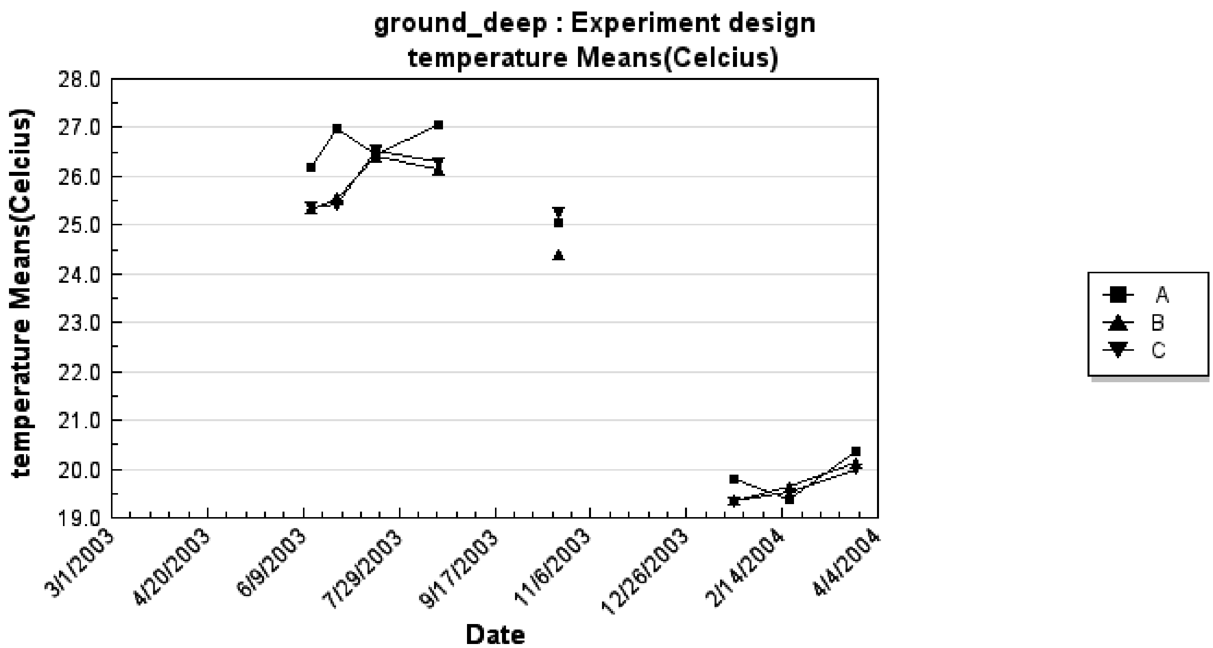

Figure 29. Temperature (Celsius) by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004

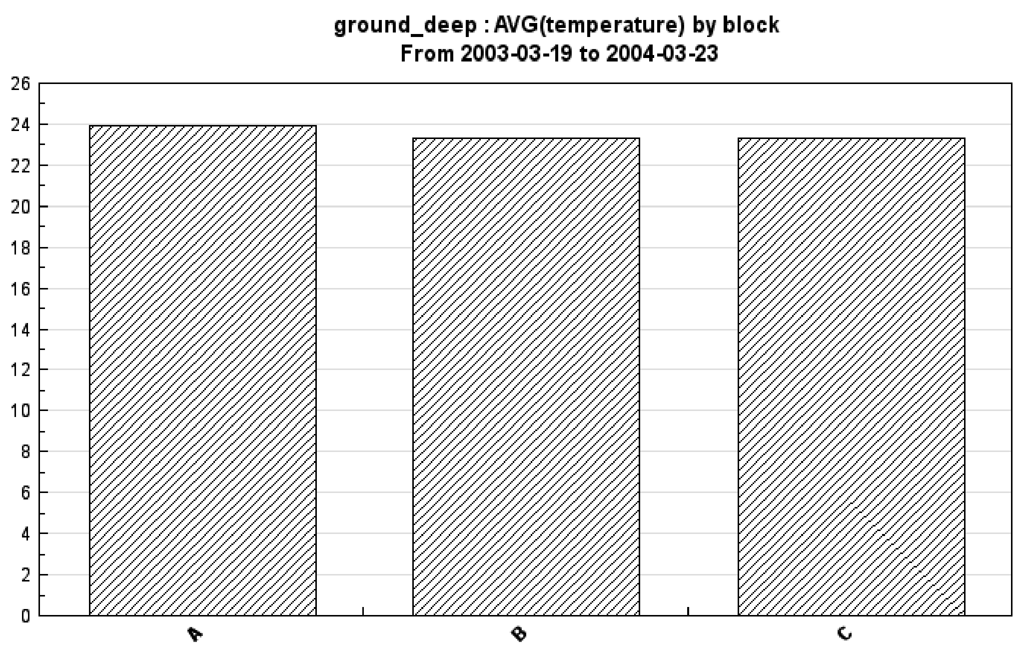

Figure 30. Temperature (Celsius) by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004

Deep Wells Physical Parameters: Electro-conductivity (EC)

Table 10. Electro-conductivity (µS) as measured in deep ground water wells between March 19, 2003 and March 23, 2004

ID	03/19/03	06/13/03	06/27/03	07/17/03	08/19/03	10/20/03	01/20/04	02/18/04	03/23/04
A1	177	193	217	231	278	208	234	220	220
A2	181	199	164	239	258	175	206	206	201
A3	110	154	133	180	163	92	167	197	199
A4	153	160	114	160	208	142	125	187	204
A5	164	153	112	192	177	153	159	130	133
A6	174	198	168	199	226	161	157	166	170
A7	152	186	164	196	191	195	195	198	204
A8	258	291	331	370	211	259	261	277	215
A9	254	216	234	280	270	222	206	211	208
A10	191	196	172	223	157	149	154	159	167
A11	128	154	140	162	175	142	163	174	187
A12	187	144	126	168	144	163	187	185	153
A13	244	214	223	275	263	214	222	217	202
A14	194	193	172	228	262	173	177	166	162
A15	179	191	137	176	164	129	172	167	145
A16	124	133	108	142	136	151	188	197	195
A17	200	180	200	216	205	170	190	197	185
B1	225	271	242	281	255	261	272	287	260
B2	321	297	320	338	353	278	280	273	272
B3	302	312	301	371	292	445	319	334	310
B4	589	377	590	750	513	426	458	442	399
B5	325	337	377	389	413	238	425	389	359
B6	80	303	276	336	227	200	249	264	256
B7	183	242	241	192	117	101	162	149	149
B8	115	147	103	147	104	195	102	110	114
B9	233	198	192	248	194	211	162	190	189
B10	238	219	200	253	235	125	196	191	191
B11	181	167	124	189	158	127	167	188	189
B12	136	168	190	243	175	129	135	148	153
B13	163	152	126	270	169	159	128	153	145
B14	113	140	87	169	141	146	124	131	158
B15	117	101	88	112	98	113	102	107	111
B16	121	181	125	178	197	141	124	134	139
B17	125	191	118	281	166	169	121	123	116
C1	177	184	152	181	200	164	186	188	199
C2	246	164	246	195	273	162	268	193	200
C3	248	382	247	385	266	354	244	323	286
C4	307	290	310	282	306	252	278	274	233
C5	191	198	258	170	168	199	183	184	173
C6	198	178	206	751	202	116	184	175	182
C7	177	200	251	186	209	133	198	197	178
C8	308	252	293	255	286	173	180	193	184
C9	373	321	342	306	397	323	439	473	465
C10	214	200	183	172	286	205	234	226	246
C11	144	150	167	136	127	125	175	188	190
C12	148	144	138	184	148	153	182	193	189
C13	328	314	302	339	305	224	238	230	212
C14	192	183	179	229	189	194	175	171	171
C15	201	198	196	214	196	143	136	155	136
C16	218	180	143	213	273	188	173	158	187
C17	173	140	110	136	140	124	108	121	112

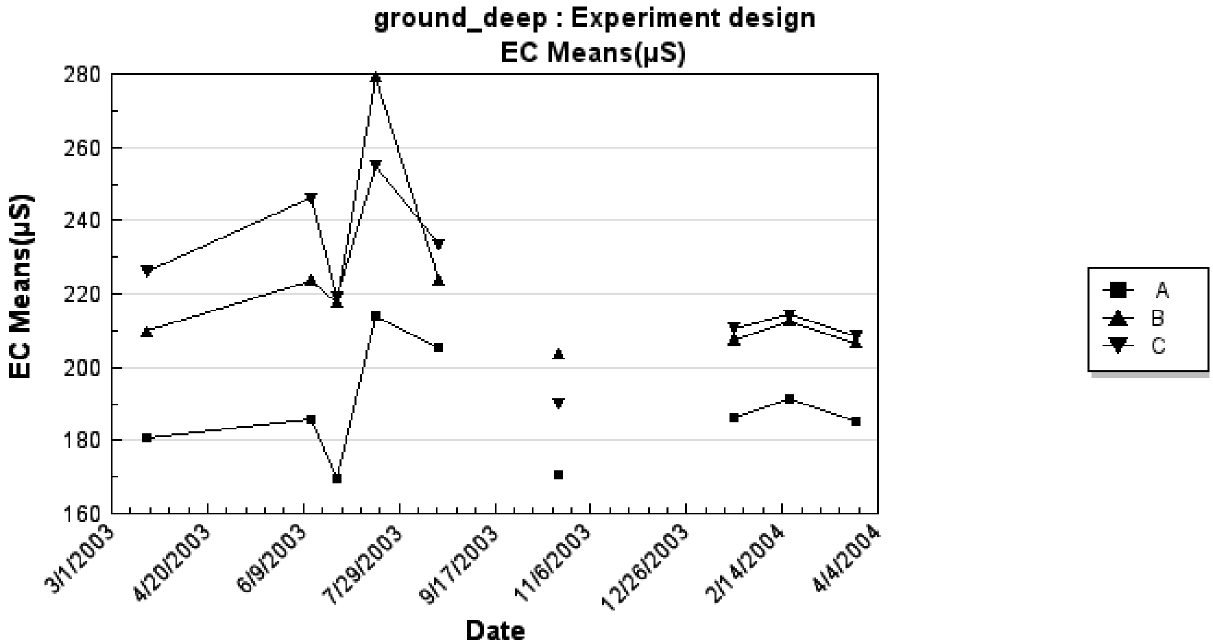

Figure 31. Electro-conductivity (µS) by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

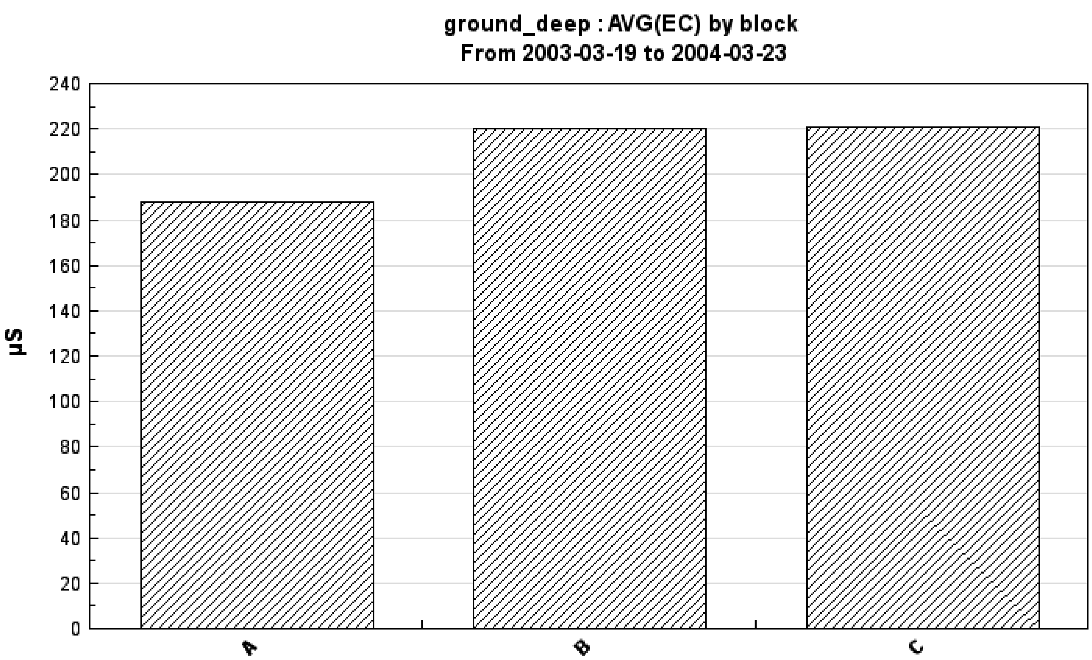

Figure 32. Electro-conductivity by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

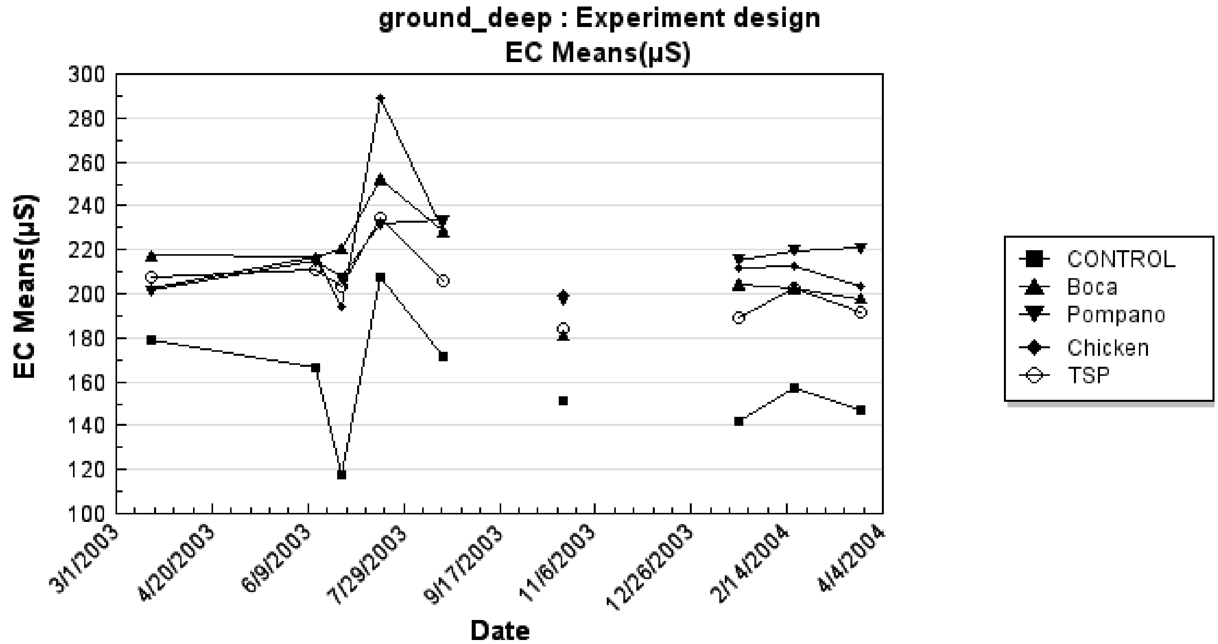

Figure 33. Electro-conductivity (µS) by fertilizer as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

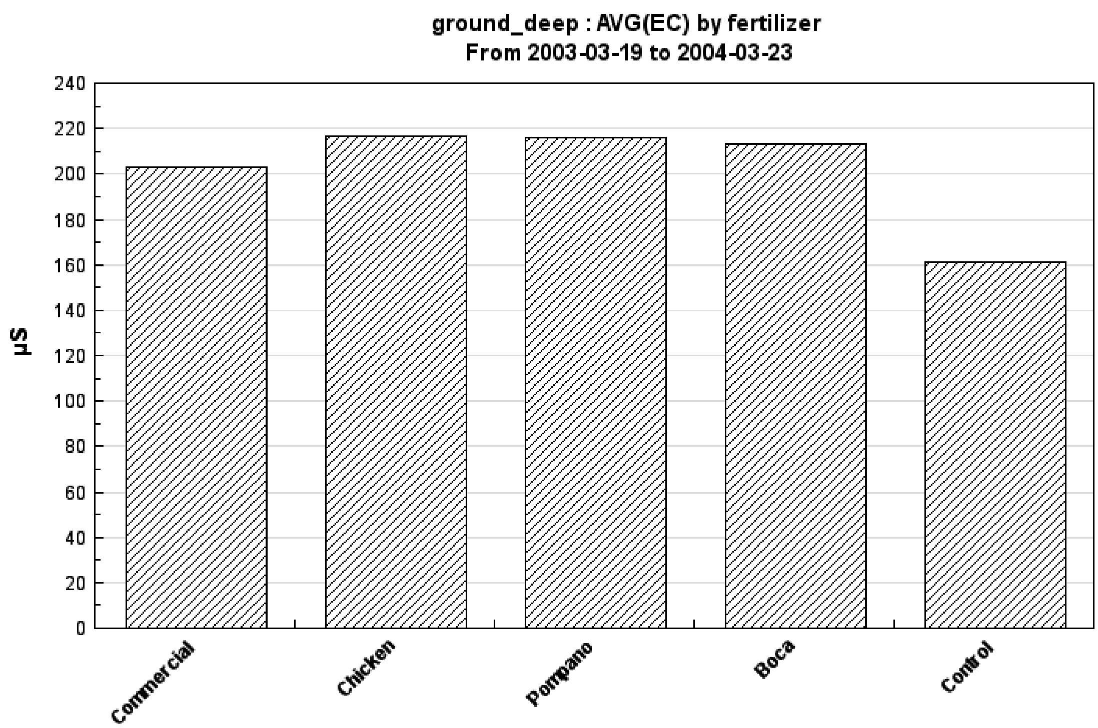

Figure 34. Electro-conductivity (µS) by fertilizer as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

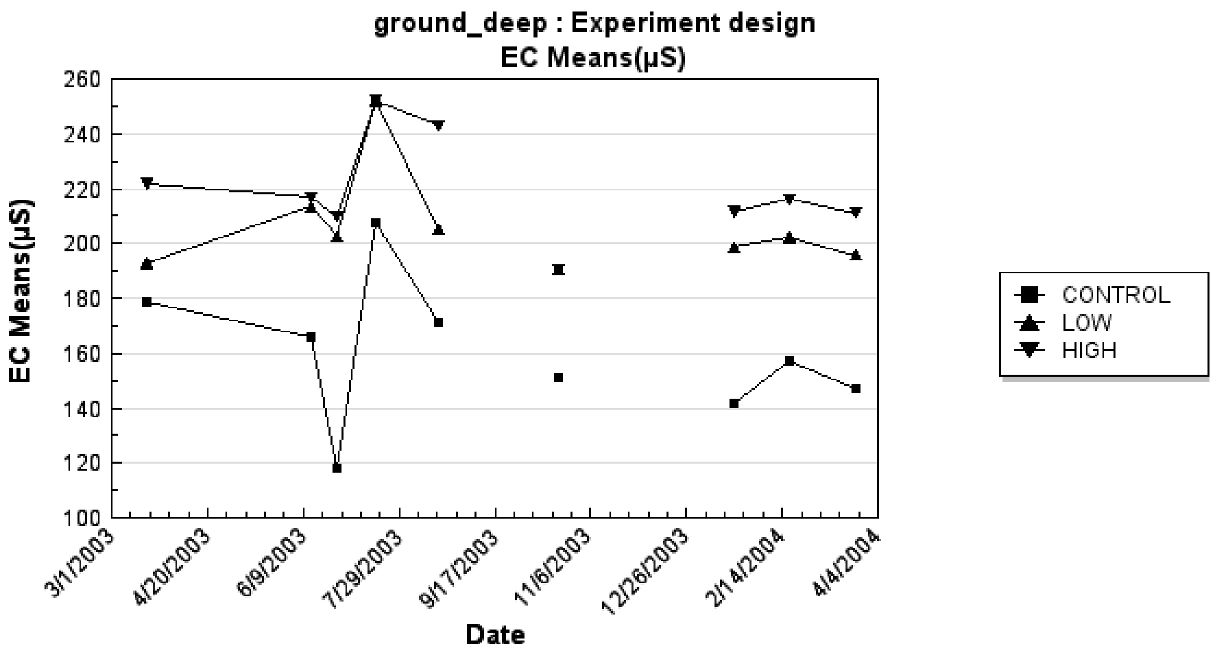

Figure 35. Electro-conductivity (µS) by amount as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

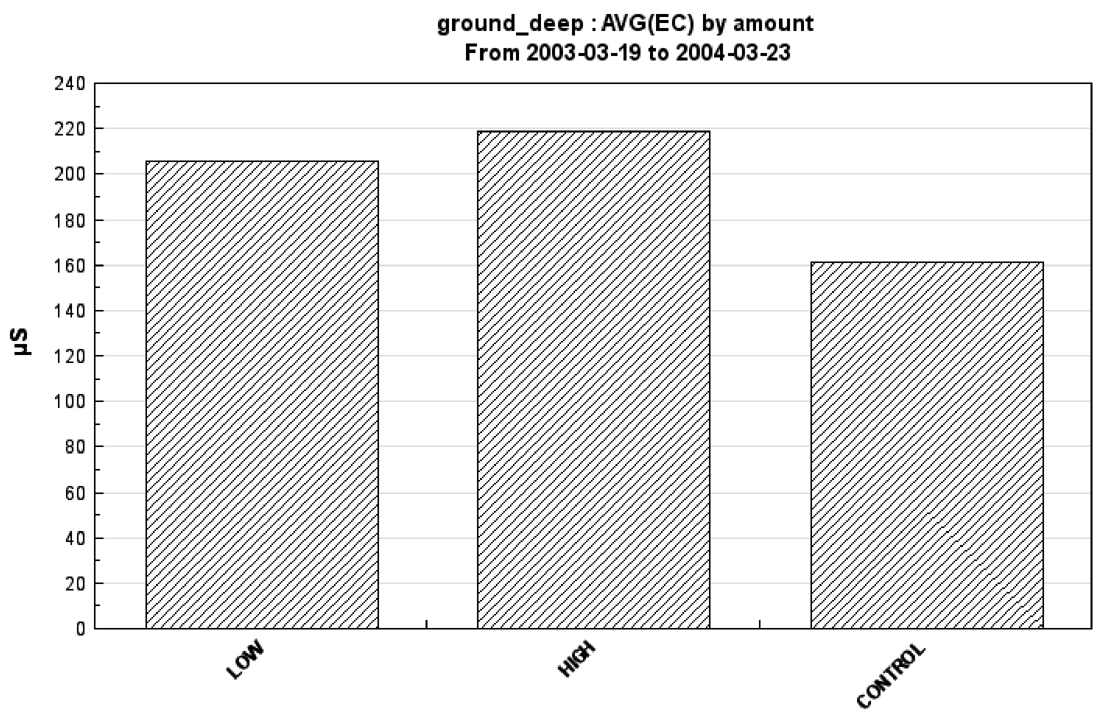

Figure 36. Electro-conductivity (µS) by amount as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

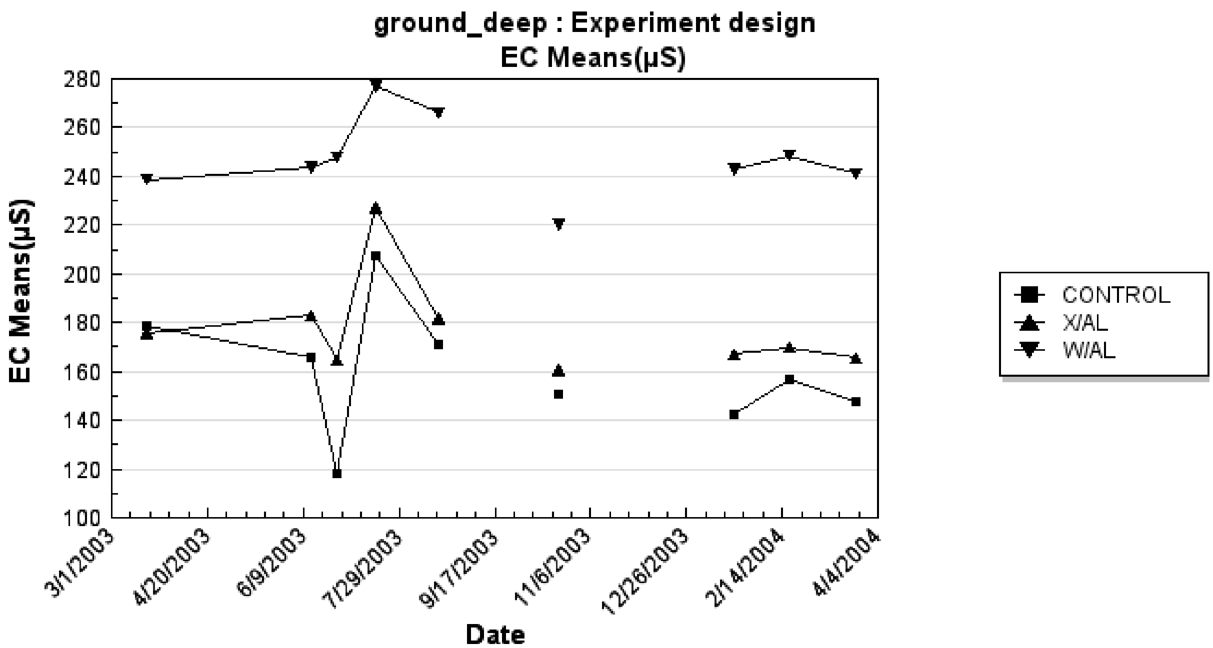

Figure 37. Electro-conductivity (µS) by alum as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

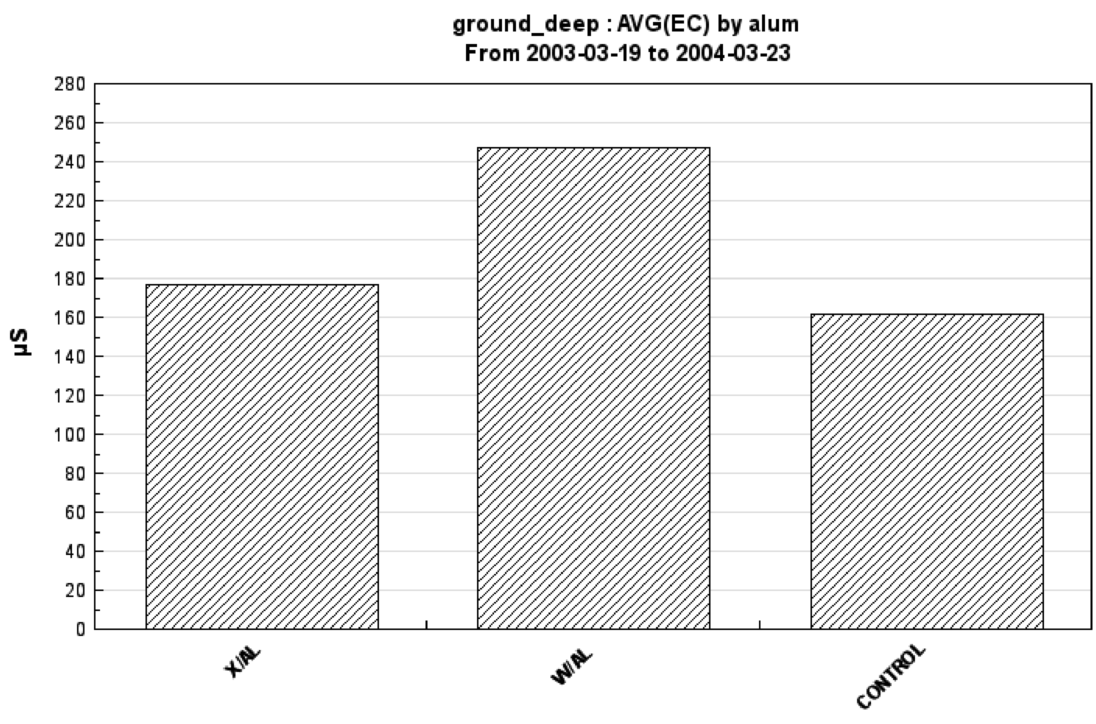

Figure 38. Electro-conductivity (µS) by alum as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

Descriptive Statistics: EC_deep

Variable	N	Mean	Median	TrMean	StDev	SE Mean
EC_deep	432	212.13	191.50	203.83	86.47	4.16

Variable	Minimum	Maximum	Q1	Q3
EC_deep	80.00	751.00	160.25	246.75

General Linear Model: EC_deep versus Fertilizer, P Level, WTR, Block, Dates

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C
Dates	fixed	9	D_01_20_04 D_02_18_04 D_03_19_03 D_03_24_04 D_06_13_03 D_06_27_03 D_07_17_03 D_08_19_03 D_10_20_03

Analysis of Variance for EC_deep, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	11900	13708	4569	0.79	0.502
P Level	1	12114	12114	12114	2.08	0.150
WTR	1	533408	533408	533408	91.77	0.000
Block	2	132084	132084	66042	11.36	0.000
Dates	8	114991	114991	14374	2.47	0.013
Error	416	2418107	2418107	5813		
Total	431	3222604				

Unusual Observations for EC_deep

Obs	EC_deep	Fit	SE Fit	Residual	St Resid
20	589.000	260.860	14.846	328.140	4.39R
22	80.000	252.223	14.679	-172.223	-2.30R
56	291.000	137.040	14.846	153.960	2.06R
104	331.000	131.582	14.846	199.418	2.67R
116	590.000	259.985	14.846	330.015	4.41R
152	370.000	177.290	14.846	192.710	2.58R
164	750.000	305.694	14.846	444.306	5.94R
182	751.000	229.272	14.679	521.728	6.97R
212	513.000	277.694	14.846	235.306	3.15R
215	117.000	267.028	14.536	-150.028	-2.00R
259	445.000	222.707	14.846	222.293	2.97R
260	426.000	244.131	14.846	181.869	2.43R
308	458.000	258.777	14.846	199.223	2.66R
309	425.000	262.527	14.679	162.473	2.17R
329	439.000	261.576	14.679	177.424	2.37R
356	442.000	262.819	14.846	179.181	2.40R
377	473.000	265.617	14.679	207.383	2.77R
425	465.000	259.846	14.679	205.154	2.74R

R denotes an observation with a large standardized residual.

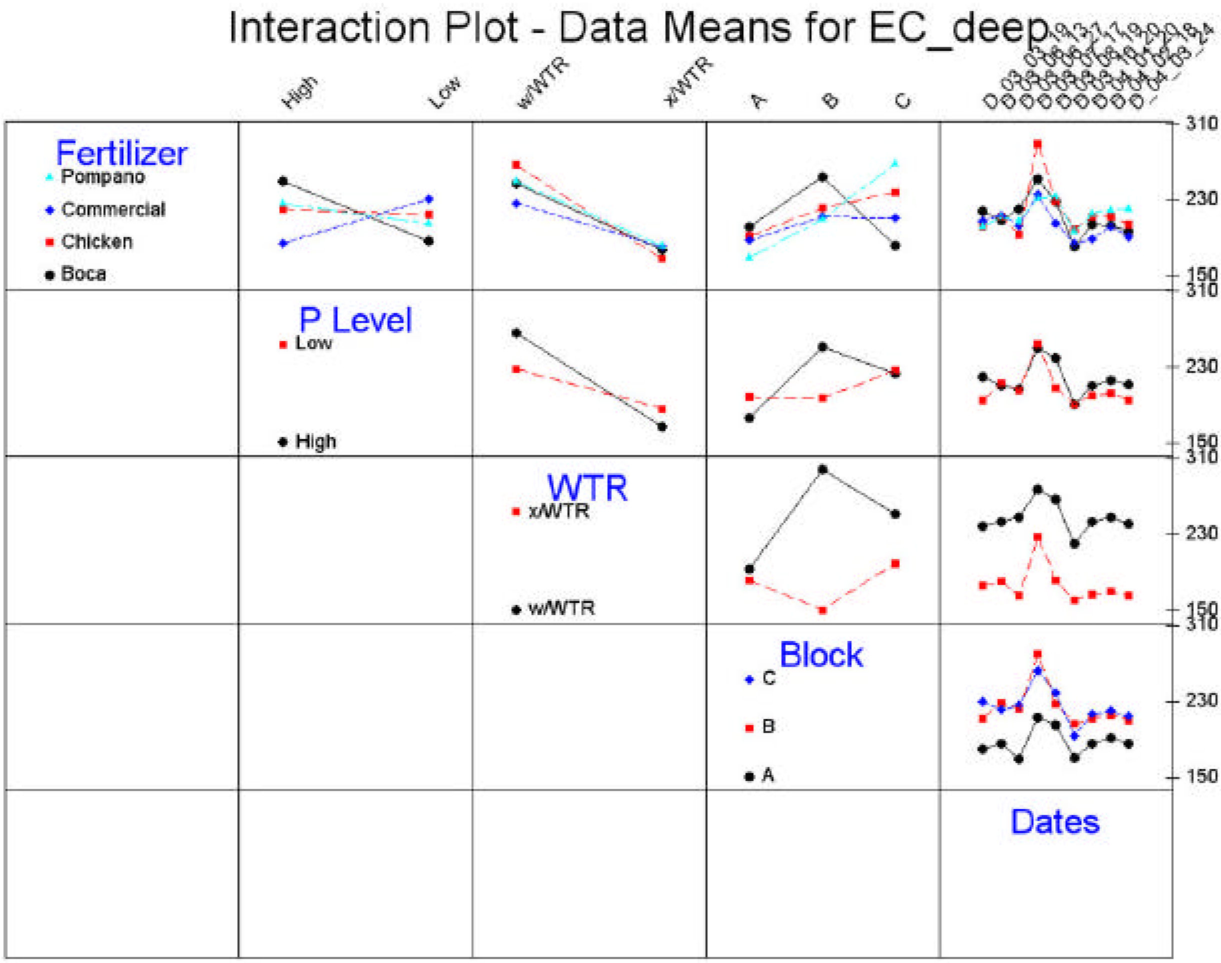

Figure 39. Interaction plot for Electro-conductivity (µS) in deep ground water wells between March 19, 2003 and March 23, 2004.

Deep Wells Physical Parameters: pH

Table 11. pH as measured in deep ground water wells between March 19, 2003 and March 23, 2004

ID	03/19/03	06/13/03	06/27/03	07/17/03	08/19/03	10/20/03	01/20/04	02/18/04	03/23/04
A1	5.24	4.83	4.58	4.63	4.57	4.60	5.31	5.05	4.66
A2	5.50	4.48	4.25	4.15	4.70	4.55	5.11	4.84	4.64
A3	4.96	3.87	4.04	3.80	5.13	4.06	4.81	4.31	3.90
A4	5.71	4.49	4.78	4.46	4.34	4.51	5.03	4.95	4.58
A5	4.14	3.31	3.51	3.41	3.33	3.55	4.05	3.97	3.50
A6	4.63	4.03	4.20	3.97	3.91	3.89	4.59	4.40	3.93
A7	4.80	4.02	3.98	3.91	4.30	4.61	5.29	5.07	4.69
A8	4.55	3.48	3.70	3.61	4.55	3.60	3.96	3.84	3.52
A9	5.13	4.47	4.44	4.50	4.09	4.15	4.61	4.63	4.00
A10	4.48	4.24	4.13	4.04	4.65	4.25	4.76	4.48	4.08
A11	4.79	4.37	4.42	4.34	4.65	4.56	5.08	4.89	4.74
A12	4.05	3.67	3.68	3.60	3.75	3.67	4.03	3.89	3.76
A13	5.37	4.92	5.05	5.08	5.07	4.73	5.00	4.85	4.37
A14	5.44	5.38	5.55	5.46	5.19	5.19	5.56	5.39	4.95
A15	4.88	3.98	4.38	4.25	3.97	4.48	4.30	4.33	4.24
A16	4.94	4.23	4.41	4.48	4.13	4.16	4.39	4.28	3.92
A17	4.66	3.96	4.37	4.10	4.52	4.06	4.25	4.15	3.88
B1	5.20	4.44	4.44	4.52	3.35	4.68	4.99	4.88	4.61
B2	5.76	5.16	5.11	5.20	4.87	5.20	5.10	5.06	4.67
B3	5.26	5.20	6.35	5.35	4.65	4.76	5.66	5.45	5.25
B4	5.13	4.53	4.61	4.74	4.64	4.94	4.91	4.75	4.48
B5	5.38	4.74	4.69	4.81	4.70	5.14	5.01	4.80	4.59
B6	5.66	5.11	5.00	5.26	5.07	4.74	5.37	5.15	5.40
B7	5.61	5.15	5.20	4.92	4.66	4.40	5.42	5.20	5.00
B8	4.74	4.08	4.20	4.14	4.10	5.12	4.76	4.47	4.45
B9	5.71	5.16	5.27	5.25	5.31	4.82	5.66	5.35	5.25
B10	5.50	4.72	4.79	4.89	4.90	4.28	5.38	5.21	4.95
B11	4.84	4.10	4.14	4.35	4.19	4.28	4.79	4.60	4.30
B12	5.16	4.84	4.85	4.63	4.44	4.24	4.92	4.63	4.45
B13	4.05	3.34	3.54	3.62	3.51	3.74	4.15	4.96	3.74
B14	4.93	4.30	4.24	4.08	4.19	4.29	4.69	4.55	4.22
B15	5.43	4.86	4.95	4.83	4.64	4.42	5.11	5.06	4.68
B16	4.10	3.50	3.58	3.63	3.69	4.03	4.26	4.20	3.87
B17	5.01	4.93	5.03	4.41	4.65	4.68	5.02	5.28	4.70
C1	5.25	4.31	4.20	4.23	4.55	4.51	5.12	4.70	4.58
C2	4.90	4.18	4.30	4.23	4.47	4.56	4.78	4.66	4.56
C3	5.71	5.82	5.20	5.59	5.22	5.07	5.75	5.55	5.28
C4	5.99	5.48	5.50	5.47	5.10	5.87	5.70	5.53	5.33
C5	5.71	5.54	5.43	5.01	4.90	5.80	5.51	5.25	5.06
C6	4.52	4.12	4.19	4.89	4.03	4.40	4.57	4.53	4.43
C7	5.69	5.38	5.40	5.33	5.00	4.70	5.67	5.61	5.26
C8	6.57	5.79	5.89	4.89	5.50	5.22	5.69	5.58	5.27
C9	5.93	6.04	5.82	5.87	5.74	5.76	6.29	6.22	5.89
C10	5.96	4.33	5.52	4.92	5.63	5.53	5.93	5.72	5.56
C11	6.30	5.15	5.02	4.90	4.86	4.72	5.08	5.87	5.07
C12	4.03	4.44	4.30	4.89	4.22	4.36	4.75	4.65	4.50
C13	5.34	4.81	4.02	4.00	4.73	4.75	5.21	5.13	4.93
C14	5.06	4.41	4.36	4.89	4.58	4.59	4.97	4.75	4.80
C15	4.97	4.30	4.33	4.89	4.33	4.37	4.76	4.55	4.51
C16	5.78	5.31	5.24	4.91	5.28	5.45	5.54	5.31	5.38
C17	5.13	4.33	4.45	4.91	4.65	4.50	4.82	4.79	4.50

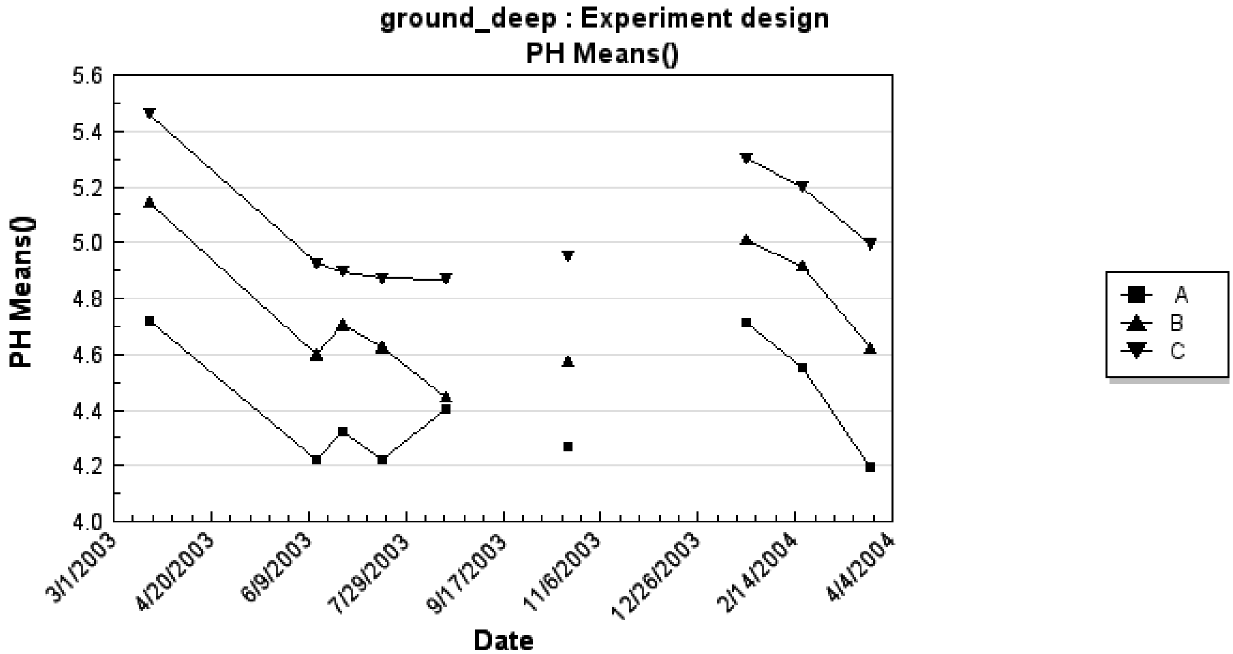

Figure 40. pH by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

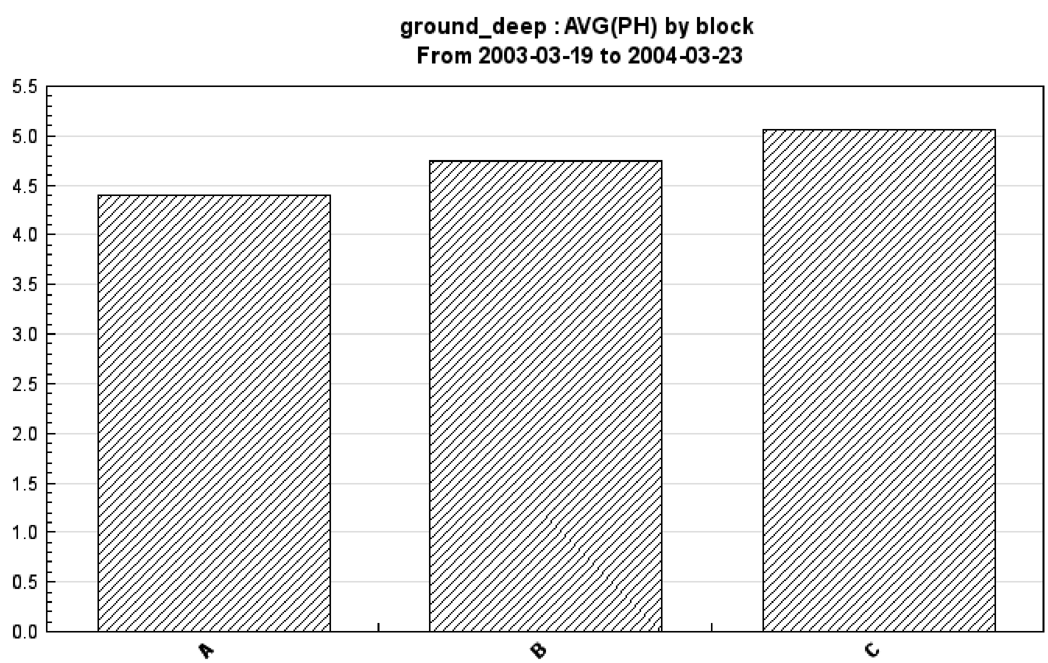

Figure 41. pH by block as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

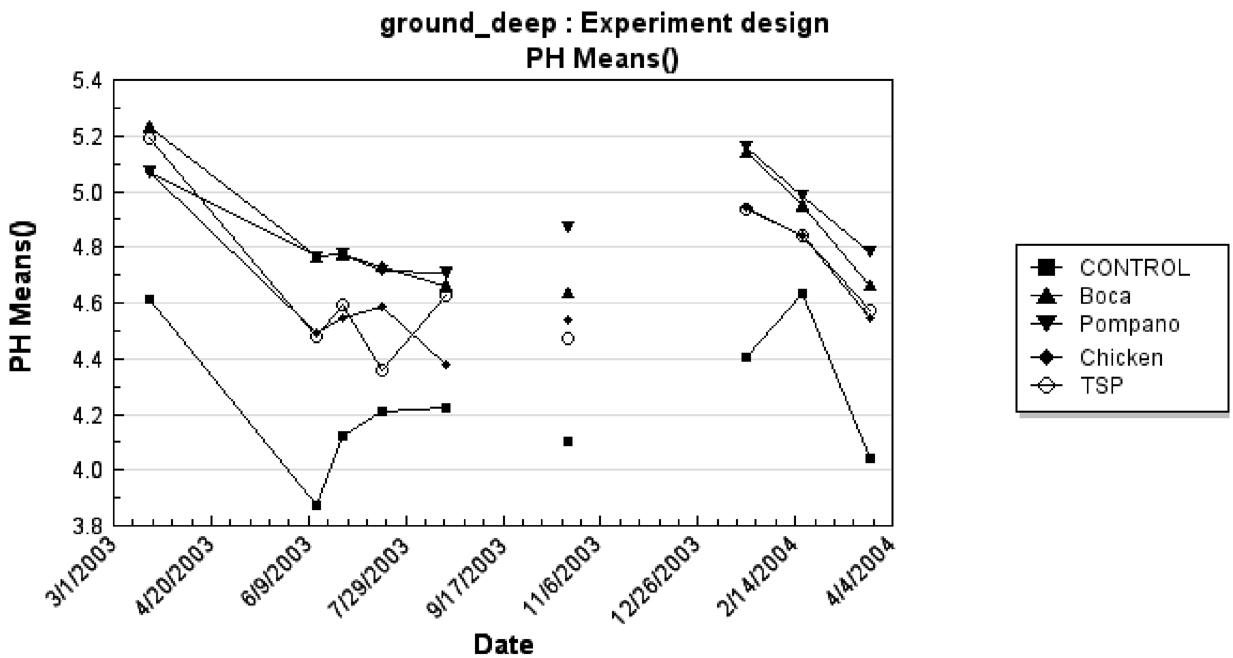

Figure 42. pH by fertilizer as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

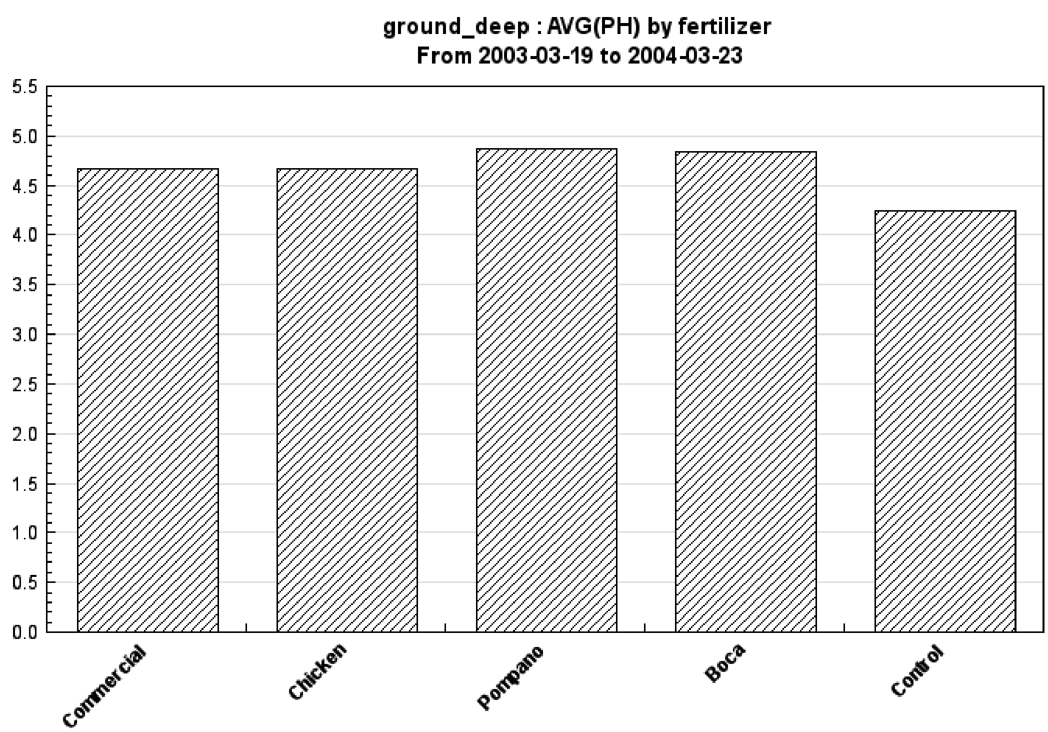

Figure 43. pH by fertilizer as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

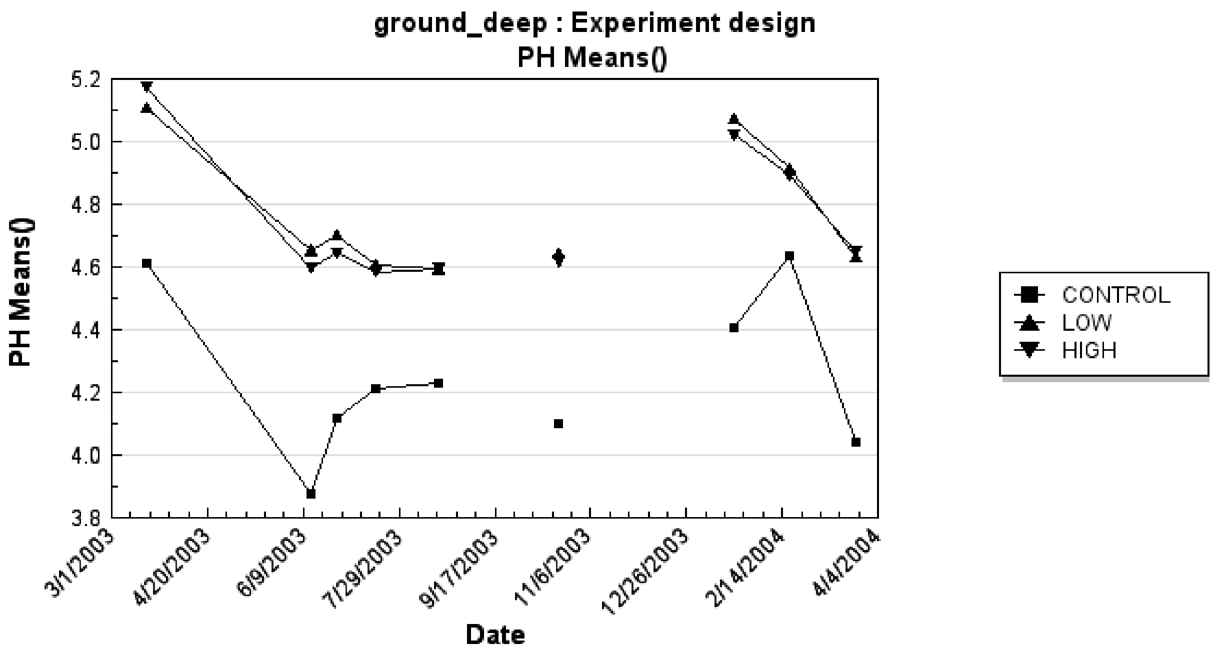

Figure 44. pH by amount as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

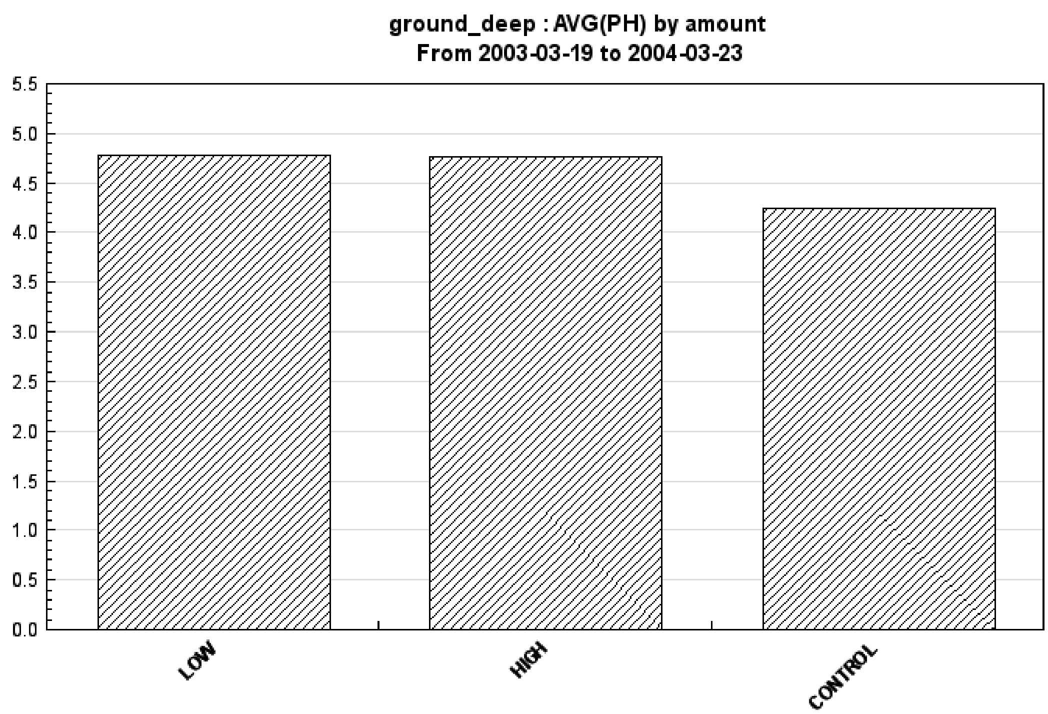

Figure 45. pH by amount as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

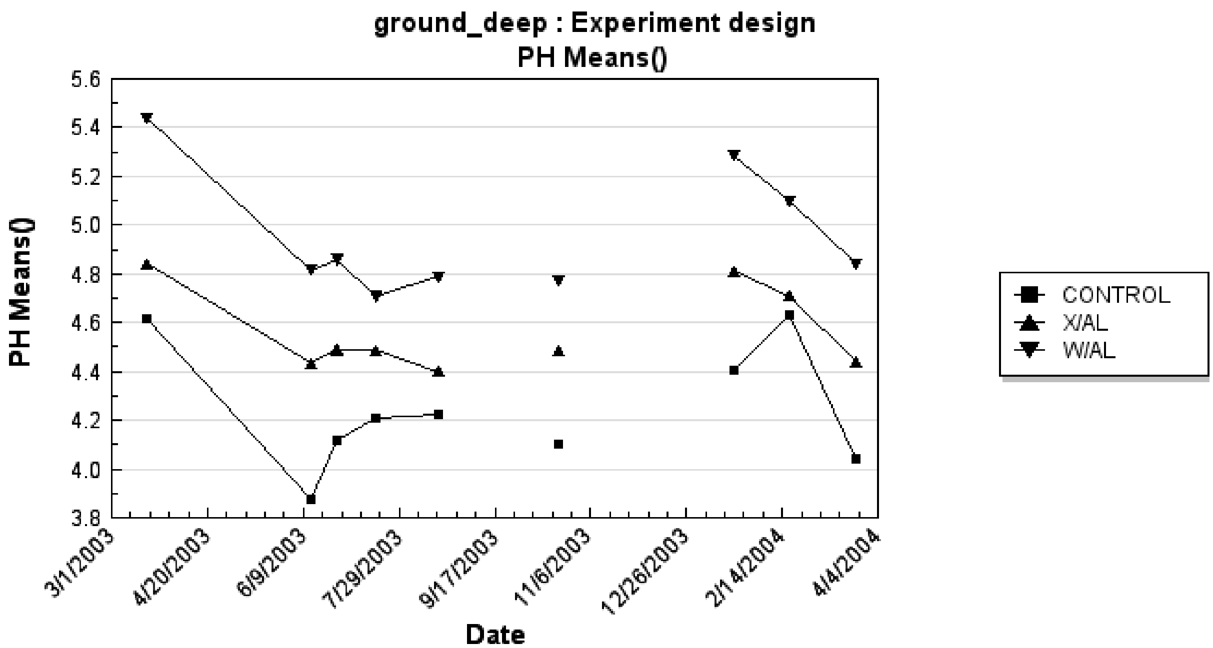

Figure 46. pH by alum as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

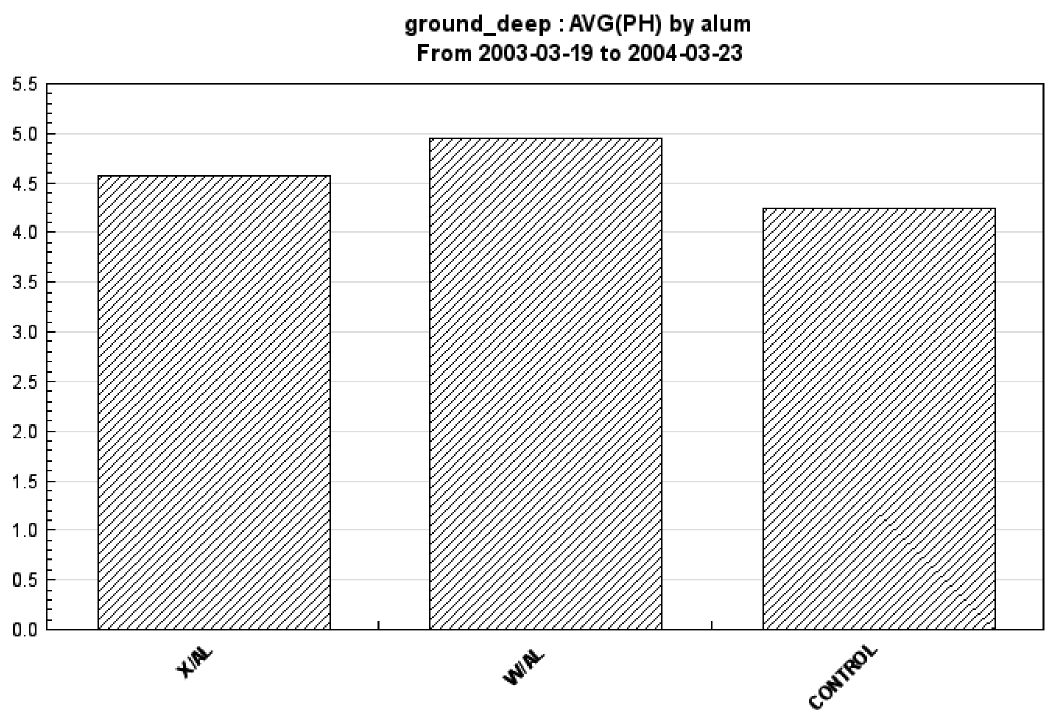

Figure 47. pH by alum as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

Descriptive Statistics: pH_deep

Variable	N	Mean	Median	TrMean	StDev	SE Mean
PH_deep	432	4.7704	4.7500	4.7704	0.5989	0.0288

Variable	Minimum	Maximum	Q1	Q3
PH_deep	3.3100	6.5700	4.3400	5.2000

General Linear Model: pH_deep versus Fertilizer, P Level, WTR, Block, Dates

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C
Dates	fixed	9	D_01_20_04 D_02_18_04 D_03_19_03 D_03_24_04 D_06_13_03 D_06_27_03 D_07_17_03 D_08_19_03 D_10_20_03

Analysis of Variance for pH_deep, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	4.3851	4.2050	1.4017	6.91	0.000
P Level	1	0.3941	0.3941	0.3941	1.94	0.164
WTR	1	15.6751	15.6751	15.6751	77.24	0.000
Block	2	30.3453	30.3453	15.1726	74.76	0.000
Dates	8	19.3636	19.3636	2.4205	11.93	0.000
Error	416	84.4253	84.4253	0.2029		
Total	431	154.5884				

Unusual Observations for PH_deep

Obs	PH_deep	Fit	SE Fit	Residual	St Resid
34	4.90000	5.86421	0.08674	-0.96421	-2.18R
40	6.57000	5.65400	0.08772	0.91600	2.07R
43	6.30000	5.27303	0.08772	1.02697	2.32R
44	4.03000	5.35725	0.08772	-1.32725	-3.00R
62	5.38000	4.19224	0.08589	1.18776	2.69R
81	4.31000	5.22113	0.08589	-0.91113	-2.06R
82	4.18000	5.28629	0.08674	-1.10629	-2.50R
110	5.55000	4.23954	0.08589	1.31046	2.96R
115	6.35000	4.83477	0.08772	1.51523	3.43R
129	4.20000	5.26842	0.08589	-1.06842	-2.42R
130	4.30000	5.33359	0.08674	-1.03359	-2.34R
141	4.02000	5.06255	0.08589	-1.04255	-2.36R
158	5.46000	4.18412	0.08589	1.27588	2.89R
177	4.23000	5.21301	0.08589	-0.98301	-2.22R
178	4.23000	5.27817	0.08674	-1.04817	-2.37R

189	4.00000	5.00713	0.08589	-1.00713	-2.28R
206	5.19000	4.16141	0.08589	1.02859	2.33R
209	3.35000	4.72935	0.08674	-1.37935	-3.12R
254	5.19000	4.19724	0.08589	0.99276	2.24R
276	5.87000	4.91032	0.08674	0.95968	2.17R
277	5.80000	4.84516	0.08589	0.95484	2.16R
302	5.56000	4.61412	0.08589	0.94588	2.14R
322	4.78000	5.70817	0.08674	-0.92817	-2.10R
350	5.39000	4.47183	0.08589	0.91817	2.08R
370	4.66000	5.56588	0.08674	-0.90588	-2.05R
379	5.87000	4.97470	0.08772	0.89530	2.03R

R denotes an observation with a large standardized residual.

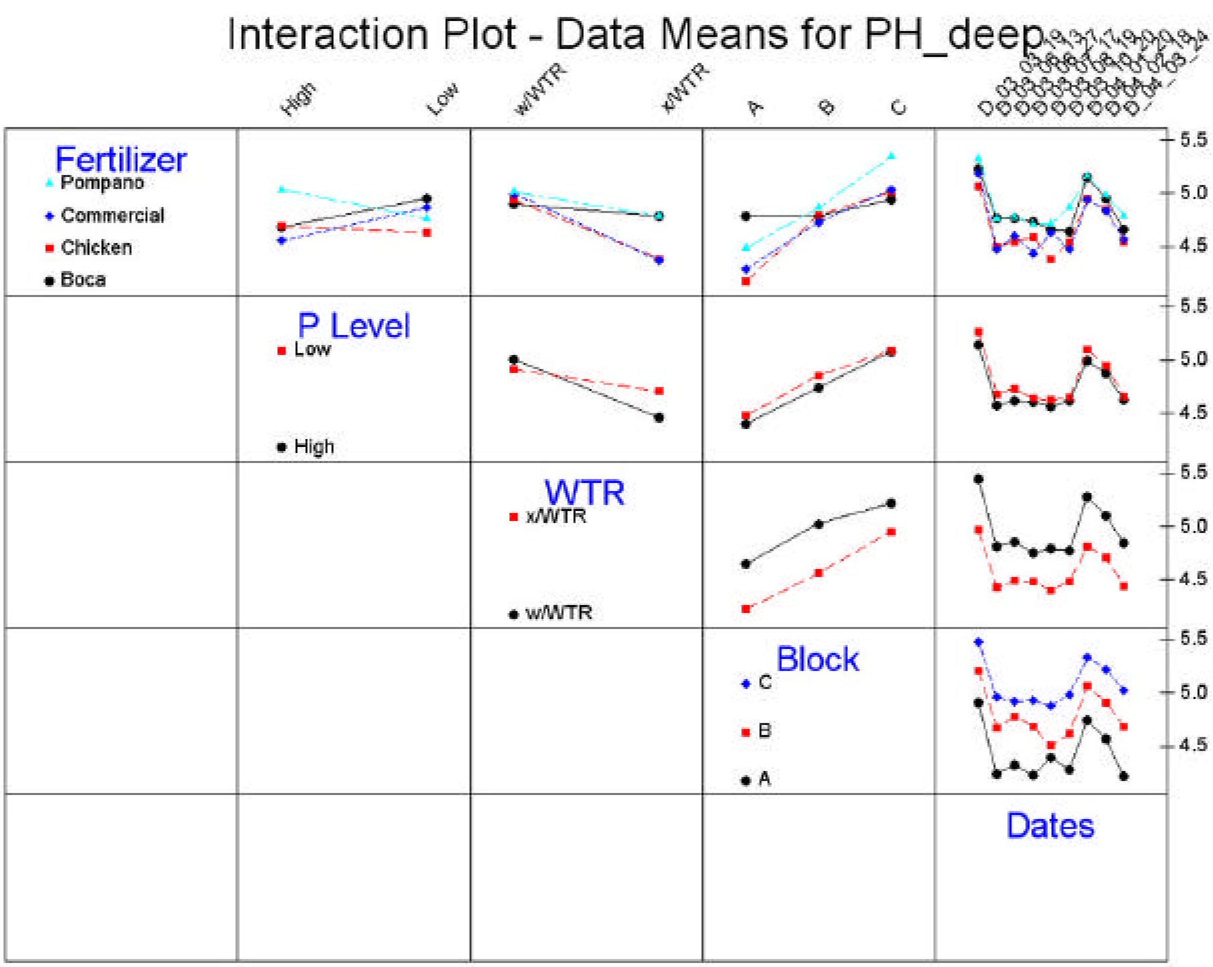

Figure 48. Interaction plots for pH as measured in deep ground water wells between March 19, 2003 and March 23, 2004.

C. SOILS

Materials and Methods

The project site soil is Immokalee sand. Immokalee is a typical Spodosol, classified in the Arenic Alaquods taxonomic group, and has distinct A, E and B_h horizons. The materials involved in the field project were A) two biosolids: a "low-soluble P" source from Pompano Beach, FL, and a "high-soluble P" source from Boca Raton, FL, B) a poultry litter, C) a TSP commercial fertilizer, and D) an Al-water treatment residual. The water treatment residual (WTR) and the poultry litter came from Bradenton and Indiantown, FL, respectively. Ammonium nitrate was applied as needed to meet N requirements for bahiagrass (179 kg N ha^{-1}).

The 90 kg ha^{-1} rate for application of P_2O_5 commercial fertilizer represents the IFAS recommended rate for bahiagrass. The plots receiving this fertilizer rate represent the P-based rate treatment. Similarly, the 179 kg N ha^{-1} rate represents the N-based rate. The TSP fertilizer P-based rate was based on the agronomic P optimum value for bahiagrass (90 kg P_2O_5 ha^{-1}). The TSP fertilizer N-based rate was 291 kg P_2O_5 ha^{-1}, and represents the rate of P applied when biosolids or manure are applied at a N-based rate. The N & P percentages and the percent solids of the biosolids, and the chicken manure were used to calculate the quantities of materials to be applied. The WTR (10% by weight) was applied first, from May 9-13, 2003. The two biosolids were applied from May 13-14, 2003. The poultry litter was applied on May 14, 2003. The TSP commercial fertilizer was applied on May 19, 2003. Ammonium nitrate was applied from May 23-26, 2003, to the P-based treatments of the biosolids and the manure to equalize the N supplied by the amendments that differ in total N levels. No ammonium nitrate was applied to the N-based treatments except for the TSP. The study field was mowed a week prior application of materials. However, the hay was not removed.

Soil samples were obtained on June 25, 2003 (approximately a month after completion of materials application). General and P-specific characterization was done on the soil samples and the amendments (materials actually applied). The results of chemical analysis of soil samples are shown in Tables 12 – 14 for the A, E, and Bh horizons, respectively. Another set of soils samples were collected on January 26, 2004 but results are not yet available.

Portions of the applied amendments were air-dried and ball-milled for analysis. The soil samples were air-dried and passed through a 2mm sieve before analysis. pH measurements were performed on fresh materials (1:2 solid or soil: solution). For the amendments, determination of percent solids was performed by drying materials to constant weight at 105 °C. The soil samples and amendments were analyzed for total P, Fe, and Al by ICAP following digestion according to the EPA Method 3050A. Oxalate extractable P, Fe, and Al were determined by ICAP after extraction at a 1:60 solid:solution ratio.

Table 12. Horizon A – soil sampling results for June 25 2003.

Plot	Soil pH	P-Mehlich mg/kg	P-total mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	Fe mg/kg	Al mg/kg	Fertilizer	P level	Alum
A1	5.6	72	254	1 949	108	91	12	629	Chicken	Low	w/Alum
A2	5.1	31	N/A	1 073	86	44	11	257	Boca	High	w/Alum
A3	5.1	38	259	740	34	22	9	240	Commercial	Low	w/Alum
A4	5.1	38	396	1 349	57	30	12	217	Pompano	High	w/Alum
A5	5.2	32	211	1 196	59	35	9	141	Chicken	Low	x/Alum
A6	5.3	32	209	976	63	23	7	66	Boca	High	x/Alum
A7	5.3	45	355	1 442	80	45	12	458	Pompano	Low	w/Alum
A8	4.9	24	154	1 315	56	42	8	79	Commercial	Low	x/Alum
A9	5.6	42	298	1 689	70	48	9	181	Chicken	High	w/Alum
A10	5.0	24	194	1 396	80	42	8	57	Pompano	Low	x/Alum
A11	4.9	33	449	984	43	29	14	456	Commercial	High	w/Alum
A12	5.0	45	201	928	44	33	7	69	Chicken	High	x/Alum
A13	5.2	30	259	1 034	53	32	13	535	Boca	Low	w/Alum
A14	5.3	51	236	987	46	22	6	42	Boca	Low	x/Alum
A15	5.1	38	242	1 367	60	52	7	62	Commercial	High	x/Alum
A16	5.1	17	191	731	29	23	6	28	Pompano	High	x/Alum
A17	5.2	14	104	949	49	34	6	38	NULL	NULL	NULL
B1	5.6	40	295	1 717	109	80	10	412	Chicken	Low	w/Alum
B2	5.2	30	379	1 179	106	53	17	857	Pompano	High	w/Alum
B3	5.1	33	259	1 022	92	69	15	327	Commercial	Low	w/Alum
B4	4.9	62	469	1 737	104	58	17	455	Boca	High	w/Alum
B5	5.1	36	306	968	58	80	13	614	Chicken	High	w/Alum
B6	5.2	51	313	1 250	100	48	11	658	Pompano	Low	w/Alum
B7	5.1	30	276	1 039	37	38	11	379	Boca	Low	w/Alum
B8	5.2	39	151	1 133	43	34	6	63	Pompano	Low	x/Alum
B9	5.4	35	367	965	62	52	9	428	Commercial	High	w/Alum
B10	4.8	44	213	1 040	104	49	9	56	Boca	High	x/Alum
B11	4.7	27	162	847	53	41	7	43	Commercial	Low	x/Alum
B12	4.9	29	263	954	54	42	7	41	Pompano	High	x/Alum
B13	4.7	16	102	902	40	53	7	41	NULL	NULL	NULL
B14	4.9	11	169	1 037	36	34	7	44	Boca	Low	x/Alum
B15	4.9	14	129	645	46	40	5	34	Chicken	Low	x/Alum
B16	4.6	33	176	591	29	23	5	32	Commercial	High	x/Alum
B17	4.9	15	N/A	500	39	28	5	27	Chicken	High	x/Alum
C1	5.5	34	395	1 186	49	44	15	622	Boca	Low	w/Alum
C2	5.4	46	316	1 122	49	32	15	345	Pompano	Low	w/Alum
C3	4.9	15	283	1 192	45	55	14	422	Chicken	Low	w/Alum
C4	5.1	25	216	1 002	41	32	8	69	Pompano	Low	x/Alum
C5	4.9	31	203	1 030	49	37	8	59	Boca	Low	x/Alum
C6	4.9	23	153	927	30	37	7	48	Chicken	Low	x/Alum
C7	5.1	51	362	1 264	46	36	14	517	Boca	High	w/Alum
C8	5.2	37	275	1 199	44	35	15	674	Commercial	Low	w/Alum
C9	5.4	49	409	1 525	54	37	13	745	Pompano	High	w/Alum
C10	5.2	24	306	732	29	35	10	367	Chicken	High	w/Alum
C11	5.1	21	147	1 001	28	26	5	44	Commercial	Low	x/Alum
C12	5.0	94	322	1 082	60	29	11	66	Boca	High	x/Alum
C13	5.2	34	N/A	1 235	51	39	11	488	Commercial	High	w/Alum
C14	5.2	41	178	969	58	59	6	60	Chicken	High	x/Alum
C15	5.0	48	N/A	939	47	36	6	46	Commercial	High	x/Alum
C16	5.1	32	259	982	44	35	6	47	Pompano	High	x/Alum
C17	5.0	13	112	841	35	28	8	43	NULL	NULL	NULL

Table 13. Horizon E – soil sampling results for June 25, 2003. Reported P is Mehlich-1 extractable P.

Plot	Soil pH	P mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	Fe mg/kg	Al mg/kg	Fertilizer	P level	Alum
A1	4.8	1	41	2	0	2	8	Chicken	Low	w/Alum
A2	4.7	2	121	3	0	1	7	Boca	High	w/Alum
A3	4.5	1	43	0	0	2	4	Commercial	Low	w/Alum
A4	5.1	1	144	0	0	2	5	Pompano	High	w/Alum
A5	5.2	2	54	0	0	1	11	Chicken	Low	x/Alum
A6	4.9	1	36	0	0	1	6	Boca	High	x/Alum
A7	4.9	0	35	0	0	1	5	Pompano	Low	w/Alum
A8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Commercial	Low	x/Alum
A9	4.5	0	18	0	0	1	3	Chicken	High	w/Alum
A10	4.4	0	31	0	0	1	3	Pompano	Low	x/Alum
A11	4.4	1	16	0	0	1	3	Commercial	High	w/Alum
A12	4.6	0	28	0	0	1	3	Chicken	High	x/Alum
A13	4.5	0	30	0	0	1	3	Boca	Low	w/Alum
A14	4.7	1	35	0	0	1	4	Boca	Low	x/Alum
A15	4.8	2	15	0	0	1	3	Commercial	High	x/Alum
A16	5.3	2	92	0	0	2	7	Pompano	High	x/Alum
A17	5.4	1	15	0	0	1	2	NULL	NULL	NULL
B1	5.1	1	27	7	0	1	9	Chicken	Low	w/Alum
B2	4.6	39	175	44	1	2	675	Pompano	High	w/Alum
B3	4.8	1	16	2	0	2	239	Commercial	Low	w/Alum
B4	4.6	1	23	1	0	2	17	Boca	High	w/Alum
B5	4.7	1	71	0	0	2	15	Chicken	High	w/Alum
B6	4.7	1	64	0	0	3	14	Pompano	Low	w/Alum
B7	4.9	1	135	2	0	1	10	Boca	Low	w/Alum
B8	5.1	1	54	1	0	2	11	Pompano	Low	x/Alum
B9	5.0	2	30	2	0	3	6	Commercial	High	w/Alum
B10	4.9	2	69	0	0	2	7	Boca	High	x/Alum
B11	4.8	2	42	0	0	1	4	Commercial	Low	x/Alum
B12	4.9	1	46	1	0	1	4	Pompano	High	x/Alum
B13	4.9	0	18	1	0	1	8	NULL	NULL	NULL
B14	4.7	1	24	0	0	1	9	Boca	Low	x/Alum
B15	4.7	1	26	0	0	2	13	Chicken	Low	x/Alum
B16	4.5	25	78	0	0	2	8	Commercial	High	x/Alum
B17	4.8	1	24	0	0	3	6	Chicken	High	x/Alum
C1	4.8	0	5	0	0	1	3	Boca	Low	w/Alum
C2	4.8	1	39	0	0	3	10	Pompano	Low	w/Alum
C3	4.7	1	39	0	0	3	11	Chicken	Low	w/Alum
C4	4.7	1	43	0	0	3	8	Pompano	Low	x/Alum
C5	5.2	1	55	1	0	2	7	Boca	Low	x/Alum
C6	5.1	1	22	1	0	2	4	Chicken	Low	x/Alum
C7	4.8	1	24	0	0	1	3	Boca	High	w/Alum
C8	5.4	2	14	0	0	2	5	Commercial	Low	w/Alum
C9	4.7	1	18	0	0	1	4	Pompano	High	w/Alum
C10	4.9	1	12	0	0	2	9	Chicken	High	w/Alum
C11	5.4	1	13	0	0	1	2	Commercial	Low	x/Alum
C12	4.9	2	29	1	0	2	11	Boca	High	x/Alum
C13	4.6	2	20	0	0	1	2	Commercial	High	w/Alum
C14	5.1	1	17	0	0	1	3	Chicken	High	x/Alum
C15	5.1	2	15	0	0	2	3	Commercial	High	x/Alum
C16	5.1	1	17	0	0	1	3	Pompano	High	x/Alum
C17	5.1	1	12	0	0	1	3	NULL	NULL	NULL

Table 14. Horizon Bh – soil sampling results for June 25, 2003. Reported P is Mehlich-1 extractable P.

Plot	Soil pH	P mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	Fe mg/kg	Al mg/kg	Fertilizer	P level	Alum
A1	4.3	15	476	103	49	9	384	Chicken	Low	w/Alum
A2	4.2	19	281	75	37	8	920	Boca	High	w/Alum
A3	4.0	17	119	64	8	9	1 350	Commercial	Low	w/Alum
A4	4.4	2	438	26	5	7	176	Pompano	High	w/Alum
A5	4.2	32	158	64	19	8	865	Chicken	Low	x/Alum
A6	4.3	6	279	46	3	4	278	Boca	High	x/Alum
A7	4.1	28	223	59	5	6	651	Pompano	Low	w/Alum
A8	4.3	6	139	11	1	3	730	Commercial	Low	x/Alum
A9	4.1	9	192	16	3	5	316	Chicken	High	w/Alum
A10	4.2	9	122	41	5	6	811	Pompano	Low	x/Alum
A11	4.0	2	94	26	10	8	636	Commercial	High	w/Alum
A12	4.1	8	17	1	4	3	505	Chicken	High	x/Alum
A13	4.0	4	13	1	4	3	228	Boca	Low	w/Alum
A14	4.5	1	30	2	1	4	19	Boca	Low	x/Alum
A15	4.6	1	274	5	2	4	44	Commercial	High	x/Alum
A16	4.7	0	57	0	3	3	21	Pompano	High	x/Alum
A17	4.4	8	263	19	2	4	270	NULL	NULL	NULL
B1	4.4	59	133	155	62	12	756	Chicken	Low	w/Alum
B2	4.7	0	2	3	8	2	615	Pompano	High	w/Alum
B3	4.6	2	3	0	4	7	1 826	Commercial	Low	w/Alum
B4	4.6	0	65	7	2	5	1 216	Boca	High	w/Alum
B5	4.7	2	76	0	0	4	753	Chicken	High	w/Alum
B6	4.5	2	113	4	1	3	1 205	Pompano	Low	w/Alum
B7	4.2	11	97	27	7	6	742	Boca	Low	w/Alum
B8	4.5	6	172	7	2	5	783	Pompano	Low	x/Alum
B9	4.9	32	187	7	1	12	1 513	Commercial	High	w/Alum
B10	5.0	33	357	0	0	7	1 855	Boca	High	x/Alum
B11	5.0	13	157	1	0	3	789	Commercial	Low	x/Alum
B12	4.7	16	210	18	2	7	763	Pompano	High	x/Alum
B13	4.3	11	33	19	2	8	377	NULL	NULL	NULL
B14	4.1	5	51	2	0	3	204	Boca	Low	x/Alum
B15	4.3	4	125	8	1	7	954	Chicken	Low	x/Alum
B16	4.4	6	99	10	1	3	669	Commercial	High	x/Alum
B17	4.3	9	110	29	3	8	885	Chicken	High	x/Alum
C1	4.1	5	94	78	9	24	715	Boca	Low	w/Alum
C2	4.6	3	75	21	2	14	720	Pompano	Low	w/Alum
C3	4.8	5	165	3	0	5	1 146	Chicken	Low	w/Alum
C4	4.7	3	99	16	2	6	620	Pompano	Low	x/Alum
C5	4.6	23	277	14	2	4	603	Boca	Low	x/Alum
C6	4.4	27	243	28	3	8	616	Chicken	Low	x/Alum
C7	4.2	13	162	29	3	7	511	Boca	High	w/Alum
C8	4.2	5	154	26	3	4	158	Commercial	Low	w/Alum
C9	4.3	5	54	0	0	2	109	Pompano	High	w/Alum
C10	4.4	5	94	15	2	5	141	Chicken	High	w/Alum
C11	4.4	2	18	9	1	4	72	Commercial	Low	x/Alum
C12	4.5	2	48	15	2	6	852	Boca	High	x/Alum
C13	4.5	14	131	83	9	12	628	Commercial	High	w/Alum
C14	4.5	4	148	31	2	4	945	Chicken	High	x/Alum
C15	4.3	18	113	37	7	5	584	Commercial	High	x/Alum
C16	4.2	16	129	40	3	7	802	Pompano	High	x/Alum
C17	4.1	5	45	30	2	5	502	NULL	NULL	NULL

Results

Right before amendment application (May ’03), amendment subsamples were collected and analyzed to confront their original chemical composition that was used to calculate their N and P-based application rates (Table 1). We hypothesized that chemical composition of the amendments would have not been significantly different from the initial amendment characterization (two years ago). Re-analysis of the amendments actually applied in the field made us to reject the hypothesis, since current analyses were significantly different (Table 1). All amendments, except the WTR, exhibited greater total P values than the total values that were the basis for calculating amendment application rates in 2001. Similar increase was observed for total Al values for all except the chicken manure. Total Fe decreased in all amendments since 2001.

Specifically, pH values ranged from 5.2 for the WTR, to 7.6 for the Pompano, and the Boca Raton biosolids. The chicken manure pH was slightly basic (7.7). The percent solids also varied with amendment; the biosolids Boca Raton and Pompano had similar values (~ 14%), the WTR had 62.5% solids, and the manure 25.1%. On a dry matter basis, Boca Raton had the greatest amount of total P (47.3 g kg^{-1}). Pompano biosolids total P was 30.9 g kg^{-1}, followed by the chicken manure (28.3 g kg^{-1}), and the Al-WTR that had 2.7 g total P kg^{-1}. Total Al plus Fe (35.5 g kg^{-1}) for the Boca Raton biosolids, and 38.1 g kg^{-1} for the Pompano biosolids are common values for biosolids, except when Fe or Al is added intentionally to lower P levels during the wastewater treatment process. The WTR exhibited total Al value of 98.7 g kg^{-1}, within the typical range of total Al values for WTR (50- 150 g kg^{-1}, ASCE, 1996). The chicken manure had little total Al and Fe (1.3 g kg^{-1}) typical of poultry manure chemical composition.

Oxalate extractable P, Fe, and Al are usually associated with the amorphous phase of the particles. Oxalate extractable P and Al in the WTR were approximately 90% of the total P and Al, respectively. This shows the amorphous nature of the WTR. Oxalate extractable Fe plus Al in the Boca Raton biosolids was 28.0 g kg^{-1}, and 16.7 g kg^{-1} for the Pompano biosolids, well within the typical range (10-80 g kg^{-1} by weight) found for biosolids. The chicken manure had little oxalate extractable Fe and Al (0.6 g kg^{-1}), typical values found for manures.

Table 15. Comparison of original and current chemical analysis of amendments (oven dry basis).

Source	Form	Time of analysis	pH	% Solids[@]	Total (g kg $^{-1}$)[¶]			0.2M Oxalate (g kg $^{-1}$)[†]		
					P	Al	Fe	P	Al	Fe
Indiantown	Chicken Manure	**10/03**	7.7	25.1 ±0.1	28.3 ±1.1	0.5 ±0.07	0.8 ±0.1	19.1 ±0.0	Bdl*	0.6 ±0.0
		6/01	6.8	27.0 ±0.4	18.9 ±1.1	0.9 ±0.07	1.5 ±0.1	12.7 ±0.0	0.2 ±0.0	0.7 ±0.0
Boca Raton	Biosolids	**10/03**	7.6	14.7 ±1.1	47.3 ±2.3	15.5 ±0.4	19.9 ±0.8	40.3 ±0.9	11.8 ±0.6	15.2 ±0.5
		6/01	8.2	13.4 ±0.04	38.7 ±2.3	9.3 ±0.4	24.3 ±0.8	34.0 ±0.9	8.9 ±0.6	19.4 ±0.5
Pompano	Biosolids	**10/03**	7.6	14.3 ±0.1	30.9 ±1.2	10.5 ±0.4	27.6 ±0.4	14.4 ±0.1	4.0 ±0.0	12.7 ±0.2
		6/01	7.9	15.4 ±0.04	24.1 ±1.2	9.2 ±0.4	32.8 ±0.4	20.4 ±0.1	9.2 ±0.0	24.7 ±0.2
Bradenton	WTR	**10/03**	5.2	62.5 ±2.2	2.7 ±0.7	98.7 ±5.4	6.1 ±0.1	2.3 ±0.02	95.1 ±1.3	4.8 ±0.3
		10/02	5.4	40.6 ±1.6	3.1 ±0.7	92.4 ±5.4	6.2 ±0.1	2.98 ±0.02	91.1 ±1.3	5.2 ±0.3

[@]Mean of two samples ± standard deviation
[†] Solid: Solution 1:60
[¶] Following method EPA 3050A digestion,
* Bdl = below ICP' s detection limit (0.002g Al kg $^{-1}$).

Total P values of amendments measured in 2003 were different from the values used to calculate the amendment application rates, thus, there was a significant discrepancy in the actual amounts of amendments that went on the site (Table 16). The table shows the increased amount of total P that actually was applied to the plots, and the supplemented N to reach the N-based rate. In an attempt to conduct a P mass balance analysis, we compared the measured versus the "expected" total P values that would have been present in the field (top 5cm depth). "Expected" values were based on actual amendment application rates, and the current re-analyzed total P values of the amendments right after their application. The unamended control total soil P value was also included in the "expected" calculated values. Measured total P values were the measured soil total P values one month after amendment application. A calculated % recovery was obtained for all amendments (see Table 17):

% Recovery = (measured P / expected P)*100

Table 16. Comparison of calculated and actual amounts of P and N added with different sources.

Source	Form	Application Rate	Actual dry amendment rate (kg ha^{-1})	Original calculated P added with amendment (kg P ha^{-1})	Actual P added with amendment (kg P ha^{-1})	Supplemented N (kg N ha^{-1})	Plant available N added (kg N ha^{-1})
Indiantown	Chicken Manure	N-Based	4267	81	121	--	179
		P-Based	2057	39	58	93	179
Boca Raton	Biosolids	N-Based	4480	173	212	--	179
		P-Based	1002	39	47	139	179
Pompano	Biosolids	N-Based	5120	123	158	--	179
		P-Based	1630	39	50	122	179
Commercial Fertilizer TSP	Inorganic Fertilizer P	N-Based	633	127	127	179	179
		P-Based	195	39	39	179	179
Bradenton	WTR	N-Based	22,400	69	61	--	--
		P-Based	22,400	69	61	--	--

Table 17. Comparison of expected and measured total P values in amendment-treated soil samples.

		Amendments							
Amendment Rates		Indiantown		Boca Raton		Pompano		TSP Commercial Fert.	
		Poultry manure		Biosolids		Biosolids		Fertilizer P	
		Expected @ (mg P kg^{-1} soil)	% recovery	Expected (mg P kg^{-1} soil)	% recovery	Expected (mg P kg^{-1} soil)	% recovery	Expected (mg P kg^{-1} soil)	% recovery
N-based	No WTR	**285**	**68±5**	**421**	**59±13**	**341**	**70±12**	**296**	**71±11**
P-Based	No WTR	**192**	**85±22**	**176**	**115±19**	**181**	**102±19**	**164**	**94±5**
N-based	WTR	**364**	**83±1**	**495**	**80±26**	**418**	**94±4**	**375**	**103±15**
P-based	WTR	**275**	**101±8**	**259**	**115±34**	**264**	**124±9**	**248**	**107±4**

@ = Expected total soil P based on amendment application rates, and measured P concentrations in actual amendments applied.

For the N-based treatments, the % recovery was close to 70% for all amendments that were not treated with WTR (Table 17). However, the % recovery for all amendments treated with WTR was ±20% of the expected values. The improved percent recovery in the case of WTR-treated plots may be due to P sorption by the WTRs. It seems that WTR application might have prevented the loss of some P via leaching within the timeframe (a month) of the 1st sampling after materials application.

For the P-based treatments, the percent P recovery for all amendments was greater in the case of WTR treated plots when compared to the untreated. However, for the P-based treatments, the % recovery for the untreated plots was within 15% of the expected values. Again, the % recovery for the WTR treated plots was increased when compared to the untreated. Overall, the P-based total P values were less than the N-based rate, as expected, for all amendments, with or without WTR addition.

Soil total P values measured in the field, correlated well with the amendment P application rate (Figure 49), amended with or without WTR. The more P we applied the more was found in the surface soil; the more soil P found in the case of WTR-treated plots was due to the fact that WTR contains some P (2.7 g total P kg^{-1}). The greatest absolute amount of total P was found in plots treated with Boca biosolids, followed by Pompano, litter, and the TSP fertilizer. A negative correlation was observed for the amount of P added with the % recovery (Figure 50). The more P we apply (N-based) the greater are the deviations from the expected total P values in the soil surface (smaller % recoveries). The observed deviations might be the result of P losses via leaching through the coarse textured soil. Figure 50 shows that amendment application P-based rates, show very little deviation from the expected P values independently of WTR application, as they are clustered around 100% recoveries. This might support the use of moderate P source application rates (P-based) versus to a more “aggressive” application rate (N-based).

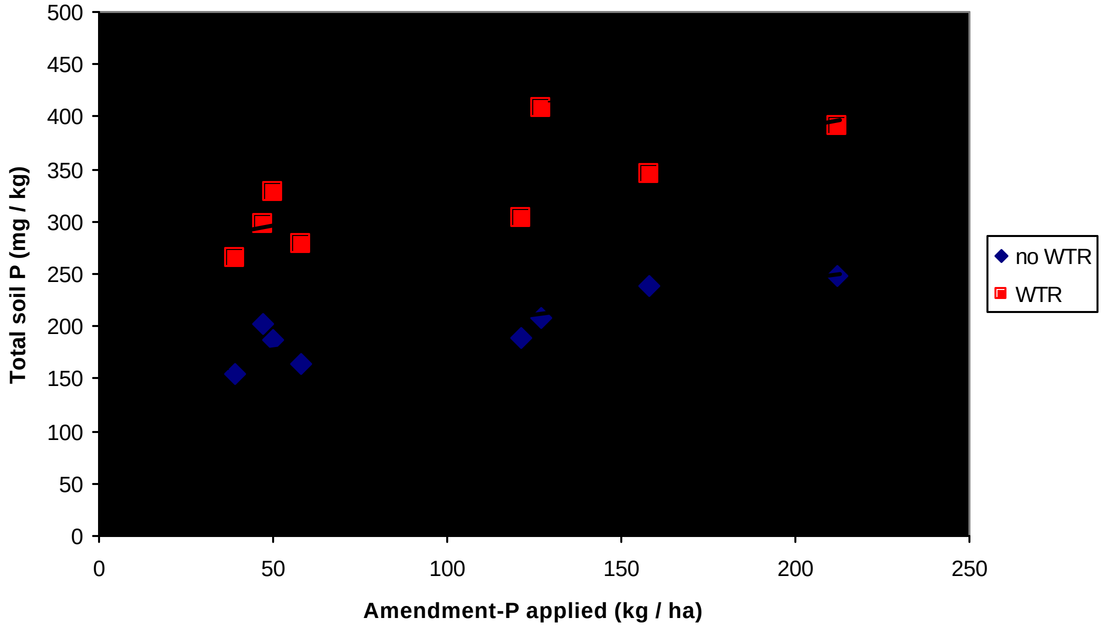

Figure 49. Total soil P measured in the field as a function of actual P added with amendments. Values are the mean value of plots (n=3) per treatment ± one std. deviation.

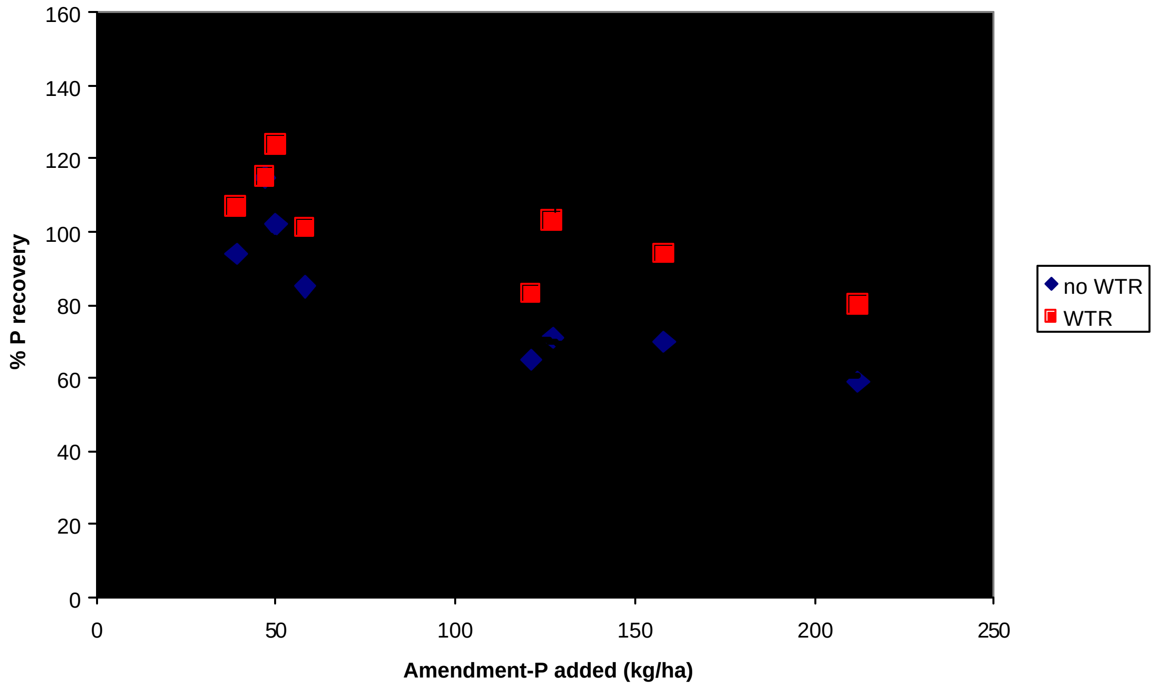

Figure 50. Percent P recovery as a function of P added with amendments. Values are the mean value of plots (n=3) per treatment ± one std. deviation.

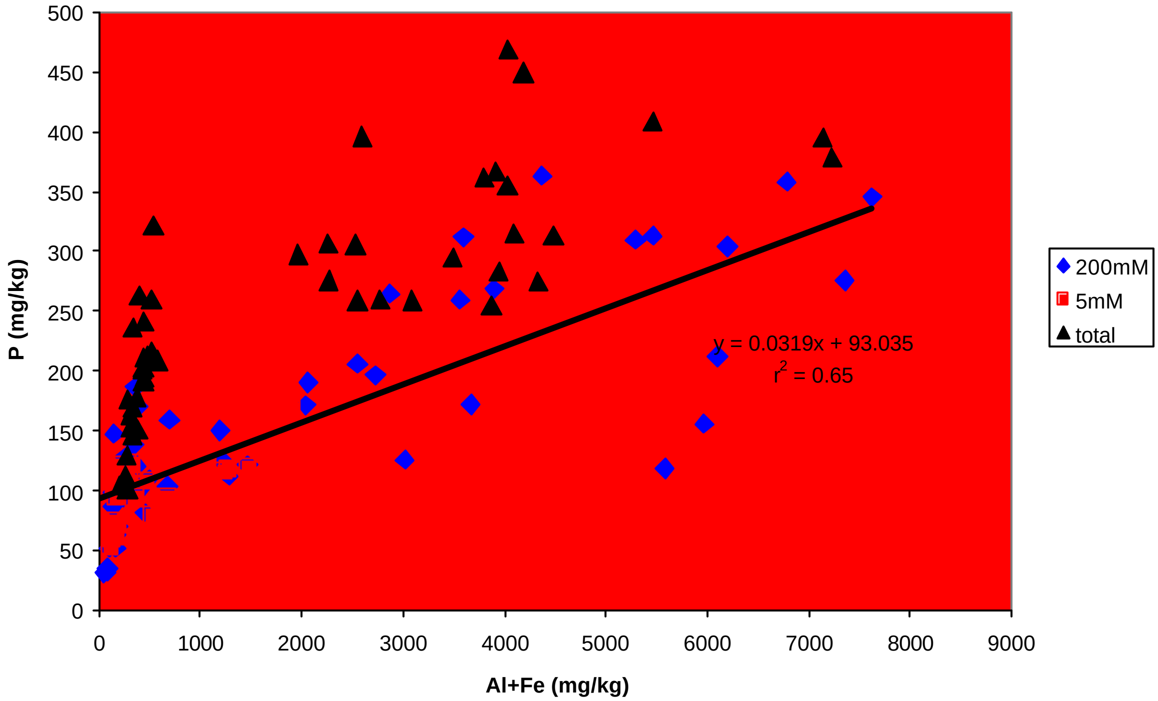

Figure 51. Different P forms (oxalate extractable 5 and 200mM, and total P) as a function of the respective oxalate-extractable and total metal (Al+Fe) values. Values are the mean value of plots (n=3) per treatment ? one std. deviation.

Total values are not considered to be a good measure of elemental bioavailability. Oxalate-extractable forms of P and metal were quantified in soil samples. We used the oxalate-extractable P and Al values to explain the increased percent P recoveries observed in WTR-treated plots. Oxalate extraction (0.2M) was able to dissolve almost 90% of the total P found in the soil samples that were not treated with WTR. A lower oxalate (5mM) concentration was also used in an attempt to differentiate between externally adsorbed P on the WTR surfaces, and internally sorbed P. A positive linear relationship was established between the oxalate (either 5 or 200mM) extractable P and the sum of Al+Fe levels in each corresponding extraction scheme (Figure 51).

Normalizing the 5mM oxalate numbers by the corresponding 200mM oxalate P, we observed that there was no difference between them when no WTR was applied (greater than 80%, Figure 52), indicating that in the absence of WTRs the activation energy of P sorption was low, and that there was one type of sites for P sorption. However, in the case of WTR-treated plots, significantly less P was extracted with 5mM compared to 200mM oxalate for all P-sources (percent oxalate P 40-65%, Figure 52). This suggests that P occupies sites on the WTR that have different activation energies, and thus, different affinities for P. This differentiation might be expressed in the form of externally sorbed P (5mM extracted), and internally sorbed P (200 mM). This trend was similar for both N and P-based treatments.

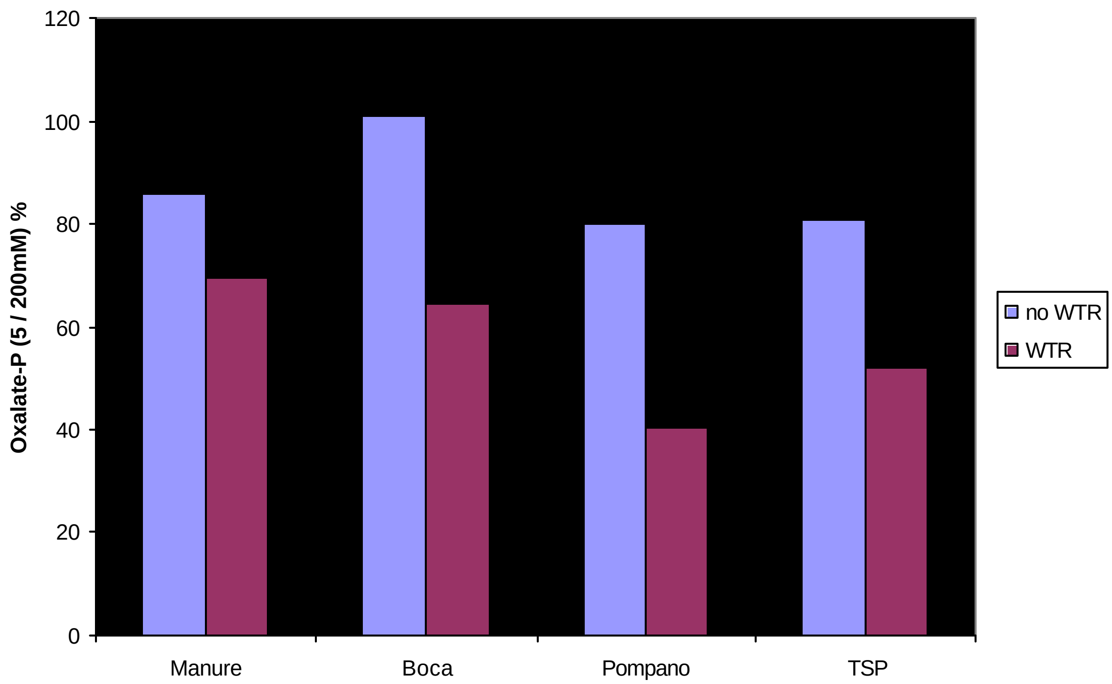

Figure 52. 5mM oxalate-extractable P levels normalized to the 200mM oxalate levels as a function of the different amendments, according to the N-based rates. Values are the mean value of plots (n=3) per treatment plus lines indicating one standard deviation.

Statistical Summary

Output from the statistical software is provided below in both tabular and graphical form. Results of the GLM analyses performed on the data are summarized in Figures 53 - 60. The statistical results show that soil horizon was a significant factor for all measured chemical parameters, pH, Mehlich- P, Ca, Mg, K, Fe, and Al. When all soil horizons were examined, the fertilizer source was significant only for K and total P, with chicken manure treated plots exhibiting higher K concentrations and lowest Total P concentrations. Block was significant for pH (Block C higher than A or B) and Al (Block B slightly higher than A and C). Fertilizer amount (P-Level low or high) was statistically significant for Total P in the horizon A only. The WTR (alum) amendment was a significant factor for Ca, Mg, K, Fe, Al and Total P. These elements were in higher concentrations on the WTR amended plots. The GLM analysis did now show WTR amendment to be significant for pH or Mehlich-P.

Mehlich-P was measured for all 3 soil horizons while Total P was measured in the A horizon only. Soil Mehlich-P content is fairly uniform in the A horizon over all treatment factors – fertilizer type, amount, WTR amendment, and block. The Mehlich-P results show clear difference by soil horizon: highest in the A horizon, lowest in the E horizon, and Bh horizon in between.

The Total P content of the A horizon showed much greater effect from the treatments factors, including fertilizer type, amount and WTR residual. The A horizon shows greater Total P content on plots where WTR was added as well as on plots where the fertilizer amount was higher. The soils on plots where the two biosolids were applied seemed to respond similarly while the plots where the chicken manure and commercial fertilizer were similar with respect to their response to fertilizer type and amount. Soil Total P content was higher for the biosolids plots.

Table 18. P-statistic values of soil analysis by GLM, as sampled on June 25, 2003.

GLM	Responses	P-statistic value				
Post-treatment		Fert	P_level	WTR	Block	Horizon
	pH	0.50	0.69	0.96	**0.08**	**0.00**
	P-Mehlich	0.84	0.55	0.24	0.92	**0.00**
	P-total	**0.00**	**0.00**	**0.00**	0.49	N/A
	Ca	0.43	0.45	**0.00**	0.11	**0.00**
	Mg	0.58	0.39	**0.00**	0.29	**0.00**
	K	**0.00**	0.30	**0.00**	0.12	**0.00**
	Fe	0.82	0.22	**0.00**	0.16	**0.00**
	Al	0.97	0.32	**0.00**	**0.00**	**0.00**

Descriptive Statistics: Soil pH, P-Mehlich, Ca, Mg, K, Fe, Al

Variable	N	N*	Mean	Median	TrMean	StDev
Soil pH	143	1	4.7867	4.8000	4.7876	0.3798
P-Mehlich	143	1	16.43	6.00	14.80	18.35
Ca	143	1	434.0	133.0	391.8	515.1
Mg	143	1	28.64	16.00	25.63	32.42
K	143	1	16.01	3.00	13.88	21.41
Fe	143	1	5.916	5.000	5.589	4.473
Al	143	1	325.2	79.0	281.9	397.4

Variable	SE Mean	Minimum	Maximum	Q1	Q3
Soil pH	0.0318	4.0000	5.6000	4.5000	5.1000
P-Mehlich	1.53	0.00	94.00	1.00	31.00
Ca	43.1	2.0	1949.0	39.0	968.0
Mg	2.71	0.00	155.00	0.00	49.00
K	1.79	0.00	91.00	0.00	34.00
Fe	0.374	1.000	24.000	2.000	8.000
Al	33.2	2.0	1855.0	10.0	620.0

General Linear Model: Soil pH, P-Mehlich, Ca, Mg, K, Fe, Al versus Fertilizer, P Level, WTR, Block, Horizon

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C
Horizon	fixed	3	A Bh E

Analysis of Variance for Soil pH, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	0.1395	0.1412	0.0471	0.79	0.499
P Level	1	0.0096	0.0094	0.0094	0.16	0.692
WTR	1	0.0001	0.0001	0.0001	0.00	0.963
Block	2	0.3053	0.2989	0.1495	2.52	0.084
Horizon	2	12.1497	12.1497	6.0748	102.53	0.000
Error	133	7.8805	7.8805	0.0593		
Total	142	20.4848				

Unusual Observations for Soil pH

Obs	Soil pH	Fit	SE Fit	Residual	St Resid
1	5.60000	5.07691	0.06422	0.52309	2.23R
9	5.60000	5.06059	0.06422	0.53941	2.30R
31	4.60000	5.09524	0.06329	-0.49524	-2.11R
64	5.30000	4.81143	0.06454	0.48857	2.08R
88	5.40000	4.87727	0.06603	0.52273	2.23R
91	5.40000	4.87539	0.06663	0.52461	2.24R
121	4.90000	4.39087	0.06319	0.50913	2.17R
122	5.00000	4.38691	0.06319	0.61309	2.61R
123	5.00000	4.38899	0.06329	0.61101	2.60R

R denotes an observation with a large standardized residual.

Analysis of Variance for P-Mehlich, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	82.7	116.3	38.8	0.28	0.839
P Level	1	30.0	49.7	49.7	0.36	0.549
WTR	1	156.5	189.1	189.1	1.37	0.244
Block	2	15.8	24.0	12.0	0.09	0.917
Horizon	2	29225.5	29225.5	14612.8	106.04	0.000
Error	133	18328.5	18328.5	137.8		
Total	142	47839.0				

Unusual Observations for P-Mehlich

Obs	P	Fit	SE Fit	Residual	St Resid
1	72.0000	36.1834	3.0973	35.8166	3.16R
29	11.0000	36.2382	3.0475	-25.2382	-2.23R
44	94.0000	36.6771	3.1583	57.3229	5.07R
66	39.0000	4.0319	3.0973	34.9681	3.09R
79	25.0000	1.5036	3.0769	23.4964	2.07R
101	32.0000	8.5287	3.1074	23.4713	2.07R
113	59.0000	11.7799	3.0995	47.2201	4.17R

R denotes an observation with a large standardized residual.

Analysis of Variance for Ca, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	64375	85884	28628	0.92	0.431
P Level	1	29555	17587	17587	0.57	0.453
WTR	1	243802	274177	274177	8.85	0.003
Block	2	178716	140298	70149	2.26	0.108
Horizon	2	33037990	33037990	16518995	533.02	0.000
Error	133	4121869	4121869	30991		
Total	142	37676307				

Unusual Observations for Ca

Obs	Ca	Fit	SE Fit	Residual	St Resid
1	1949.00	1212.75	46.45	736.25	4.34R
3	740.00	1166.87	47.76	-426.87	-2.52R
9	1689.00	1190.38	46.45	498.62	2.94R
16	731.00	1124.70	46.44	-393.70	-2.32R
17	1717.00	1143.25	46.48	573.75	3.38R
20	1737.00	1121.70	47.59	615.30	3.63R
30	645.00	1055.65	46.42	-410.65	-2.42R
31	591.00	987.40	45.77	-396.40	-2.33R
32	500.00	1033.28	46.51	-533.28	-3.14R
41	1525.00	1148.79	46.73	376.21	2.22R
42	732.00	1126.87	46.73	-394.87	-2.33R

R denotes an observation with a large standardized residual.

Analysis of Variance for Mg, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	867.6	992.3	330.8	0.66	0.578
P Level	1	490.3	365.9	365.9	0.73	0.394
WTR	1	4382.8	4662.6	4662.6	9.30	0.003
Block	2	1427.0	1243.6	621.8	1.24	0.292
Horizon	2	75446.9	75446.9	37723.4	75.28	0.000
Error	133	66648.5	66648.5	501.1		
Total	142	149263.1				

Unusual Observations for Mg

Obs	Mg	Fit	SE Fit	Residual	St Resid
18	106.000	62.507	5.942	43.493	2.02R
26	104.000	54.570	5.811	49.430	2.29R
97	103.000	40.426	5.906	62.574	2.90R
113	155.000	38.352	5.911	116.648	5.40R
129	78.000	29.764	5.820	48.236	2.23R
141	83.000	22.673	5.811	60.327	2.79R

R denotes an observation with a large standardized residual.

Analysis of Variance for K, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	1393.8	1449.1	483.0	4.51	0.005
P Level	1	161.3	116.3	116.3	1.09	0.299
WTR	1	1281.7	1381.6	1381.6	12.89	0.000
Block	2	468.8	460.6	230.3	2.15	0.121
Horizon	2	47514.4	47514.4	23757.2	221.64	0.000
Error	133	14256.0	14256.0	107.2		
Total	142	65076.0				

Unusual Observations for K

Obs	K	Fit	SE Fit	Residual	St Resid
1	91.0000	51.0069	2.7316	39.9931	4.00R
3	22.0000	43.9445	2.8085	-21.9445	-2.20R
17	80.0000	53.0008	2.7336	26.9992	2.70R
19	69.0000	45.9384	2.7854	23.0616	2.31R
21	80.0000	51.1814	2.7480	28.8186	2.89R
97	49.0000	15.9444	2.7316	33.0556	3.31R
98	37.0000	6.9456	2.7816	30.0544	3.01R
113	62.0000	17.9383	2.7336	44.0617	4.41R

R denotes an observation with a large standardized residual.

Analysis of Variance for Fe, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	6.64	6.63	2.21	0.31	0.819
P Level	1	15.67	11.14	11.14	1.55	0.215
WTR	1	257.32	270.69	270.69	37.77	0.000
Block	2	22.44	26.46	13.23	1.85	0.162
Horizon	2	1585.84	1585.84	792.92	110.65	0.000
Error	133	953.08	953.08	7.17		
Total	142	2840.99				

Unusual Observations for Fe

Obs	Fe	Fit	SE Fit	Residual	St Resid
18	17.0000	10.7498	0.7105	6.2502	2.42R
20	17.0000	11.1196	0.7237	5.8804	2.28R
114	2.0000	7.2706	0.7105	-5.2706	-2.04R
129	24.0000	8.8492	0.6960	15.1508	5.86R
130	14.0000	8.4794	0.7068	5.5206	2.14R
137	2.0000	7.9165	0.7105	-5.9165	-2.29R

R denotes an observation with a large standardized residual.

Analysis of Variance for Al, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	26487	16265	5422	0.07	0.973
P Level	1	100092	71963	71963	0.99	0.321
WTR	1	1120315	1191727	1191727	16.43	0.000
Block	2	980963	1032306	516153	7.12	0.001
Horizon	2	10552894	10552894	5276447	72.75	0.000
Error	133	9645634	9645634	72524		
Total	142	22426387				

Unusual Observations for Al

Obs	Al	Fit	SE Fit	Residual	St Resid
99	1350.00	727.81	73.05	622.19	2.40R
115	1826.00	928.47	72.45	897.53	3.46R
121	1513.00	883.21	69.91	629.79	2.42R
122	1855.00	717.30	69.91	1137.70	4.37R
136	158.00	780.22	72.45	-622.22	-2.40R
137	109.00	718.02	71.48	-609.02	-2.35R
138	141.00	711.22	71.48	-570.22	-2.20R
139	72.00	597.60	72.80	-525.60	-2.03R

R denotes an observation with a large standardized residual.

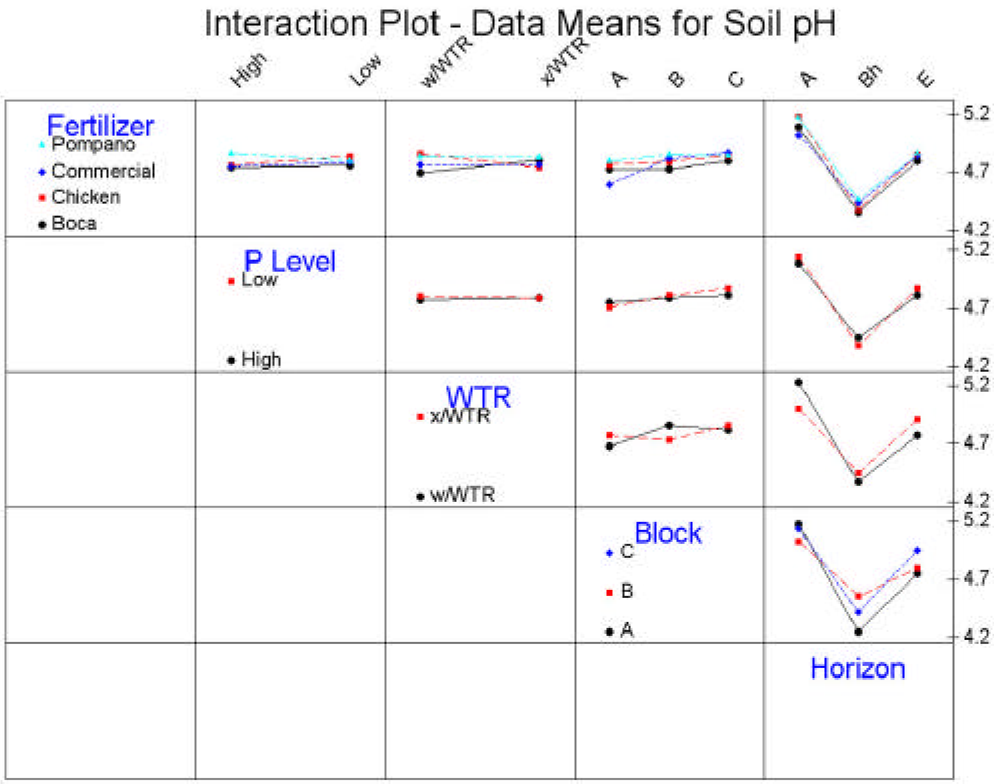

Figure 53. Interaction plot for soil pH as sampled on June 25, 2003.

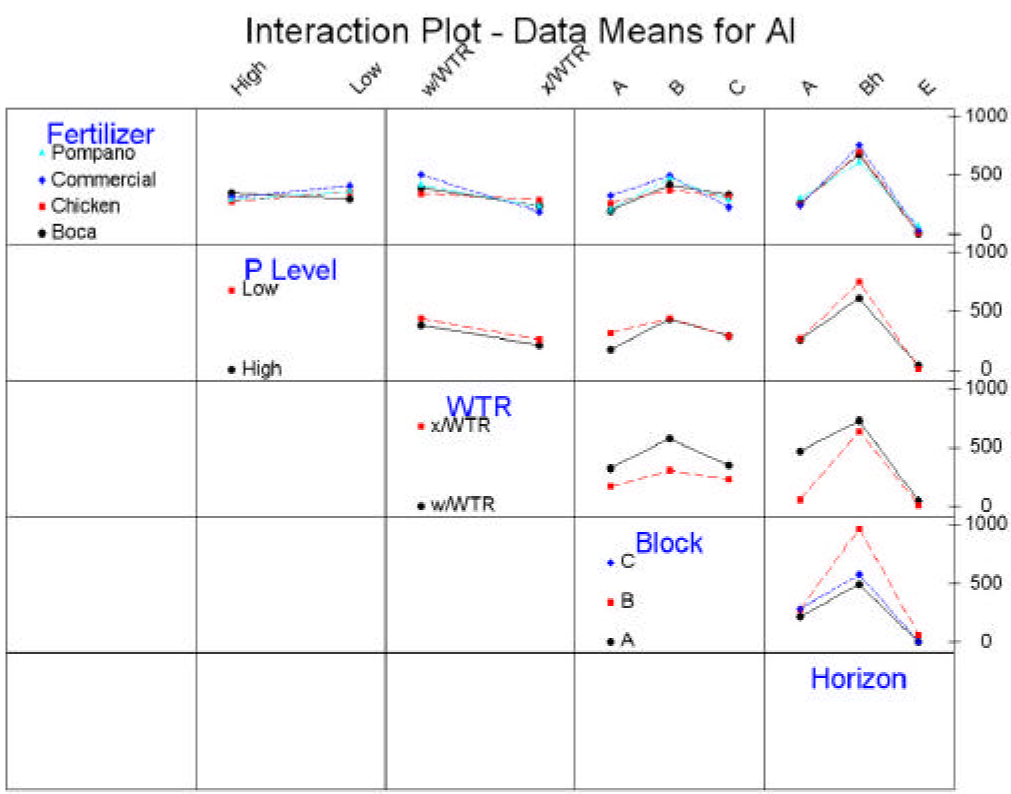

Figure 54. Interaction plot for soil Al (mg/kg soil) as sampled on June 25, 2003.

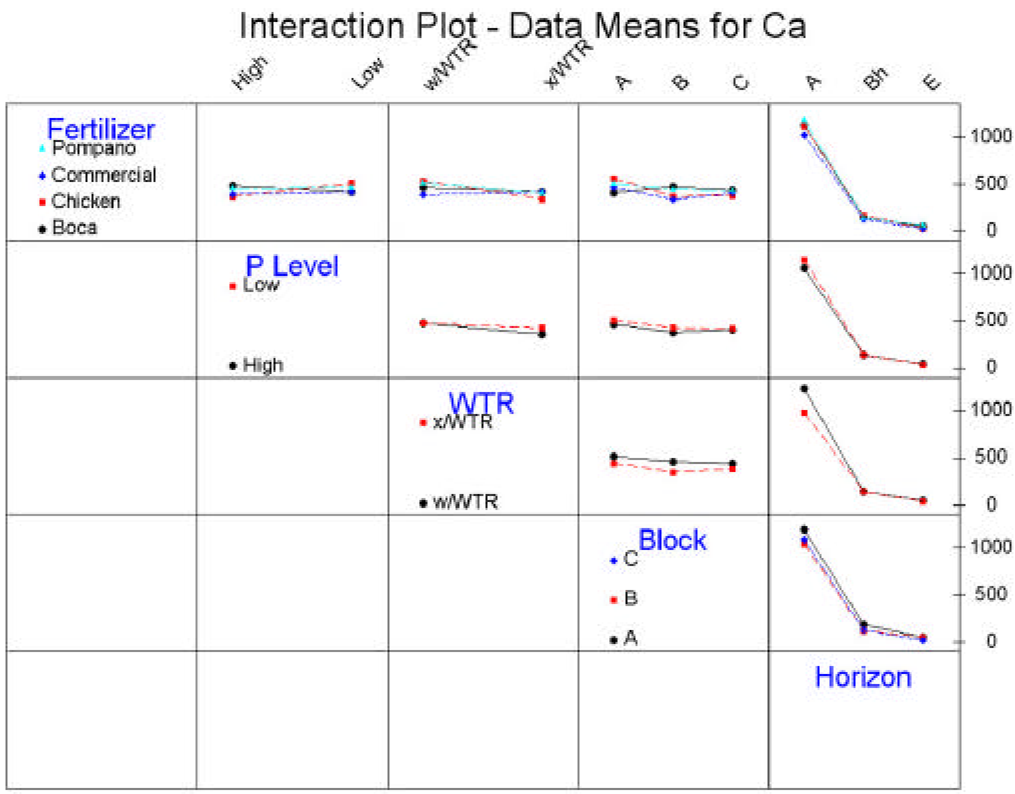

Figure 55. Interaction plot for soil Ca (mg/kg soil) as sampled on June 25, 2003.

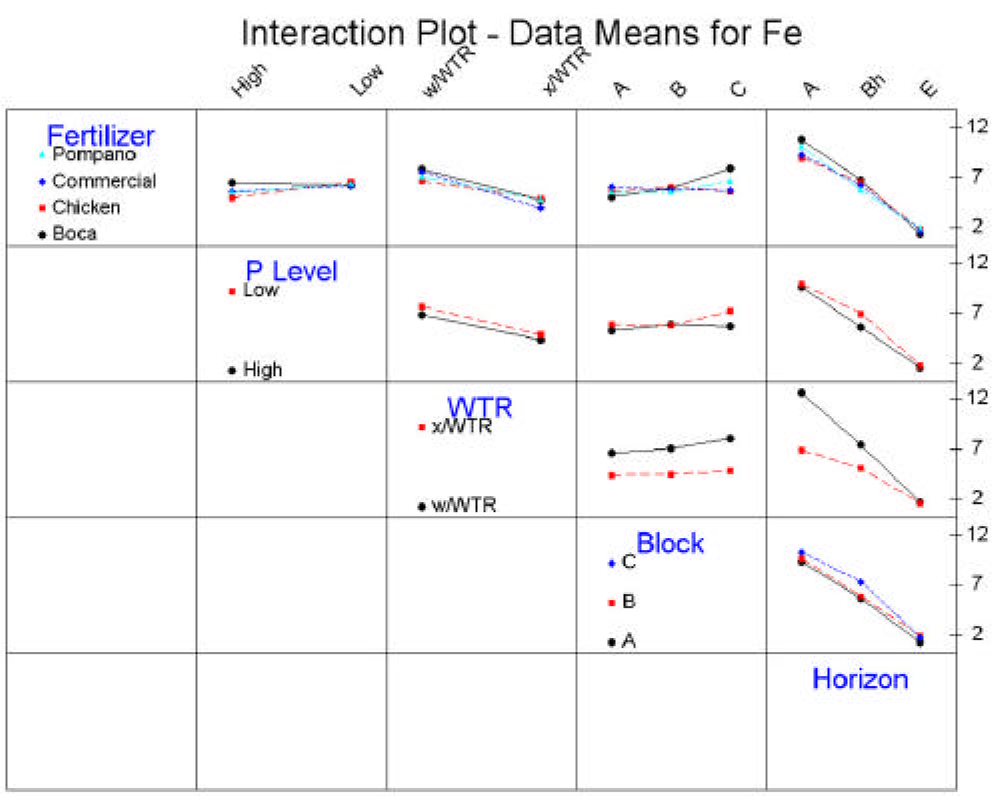

Figure 56. Interaction plot for soil Fe (mg/kg soil) as sampled on June 25, 2003.

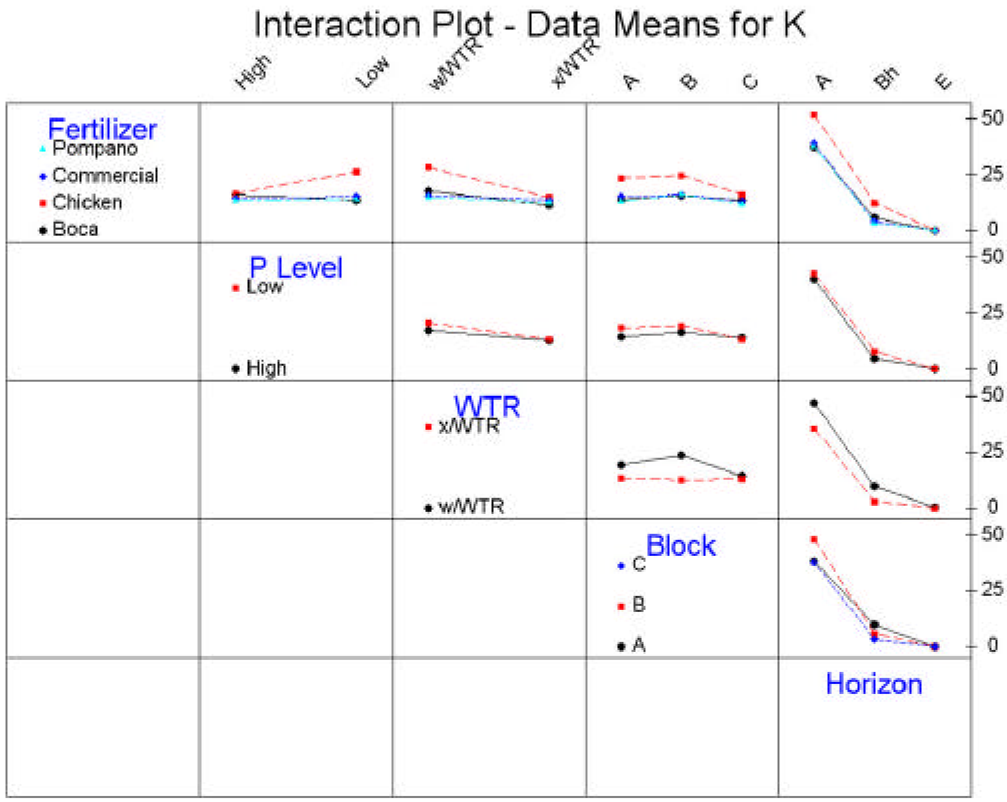

Figure 57. Interaction plot for soil K (mg/kg soil) as sampled on June 25, 2003.

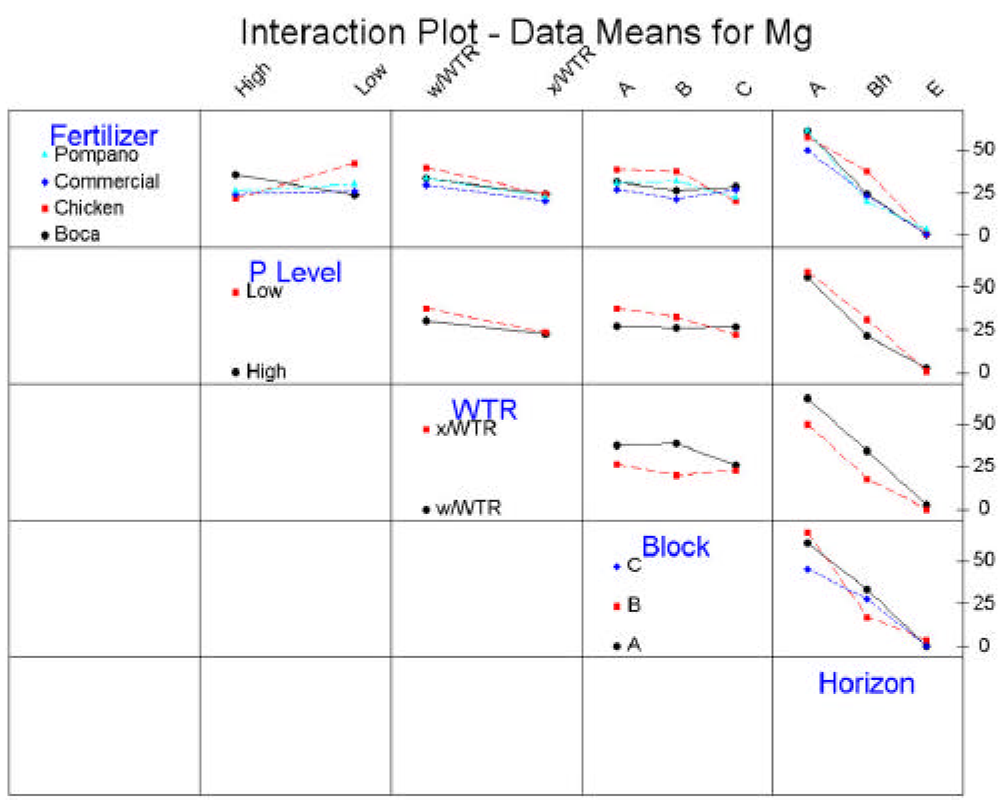

Figure 58. Interaction plot for soil Mg (mg/kg soil) as sampled on June 25, 2003.

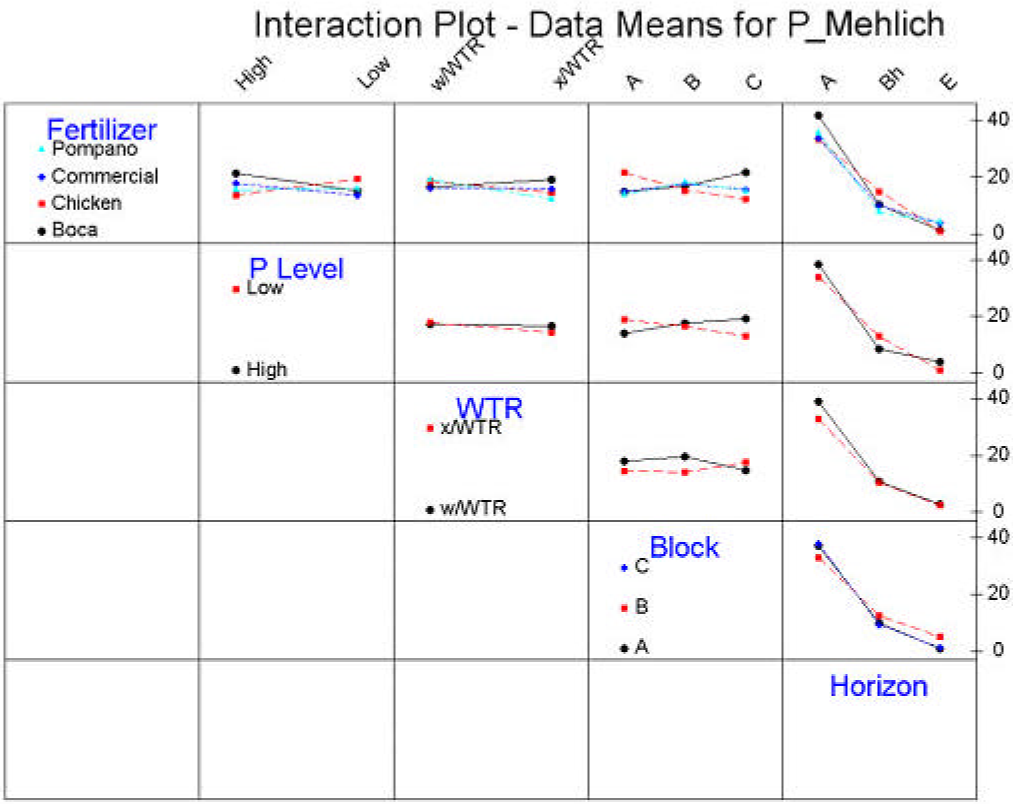

Figure 59. Interaction plot for soil P (mg/kg soil) as sampled on June 25, 2003. Reported P is Melich-1 extractable P.

Descriptive Statistics: P_total (horizon A only)

Variable	N	N*	Mean	Median	TrMean	StDev
P_total	44	4	264.9	259.1	261.5	86.5

Variable	SE Mean	Minimum	Maximum	Q1	Q3
P_total	13.0	128.6	468.6	196.1	315.0

General Linear Model: P_total versus Fertilizer, P Level, WTR, Block

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C

Analysis of Variance for P_total, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	19996	29704	9901	5.88	0.002
P Level	1	40116	41312	41312	24.52	0.000
WTR	1	198839	199909	199909	118.65	0.000
Block	2	2457	2457	1228	0.73	0.489
Error	36	60657	60657	1685		
Total	43	322065				

Unusual Observations for P_total

Obs	P_total	Fit	SE Fit	Residual	St Resid
5	211.300	136.769	17.262	74.531	2.00R
11	449.400	351.291	17.768	98.109	2.65R
13	258.700	336.214	17.843	-77.514	-2.10R
20	468.600	385.961	18.038	82.639	2.24R

R denotes an observation with a large standardized residual.

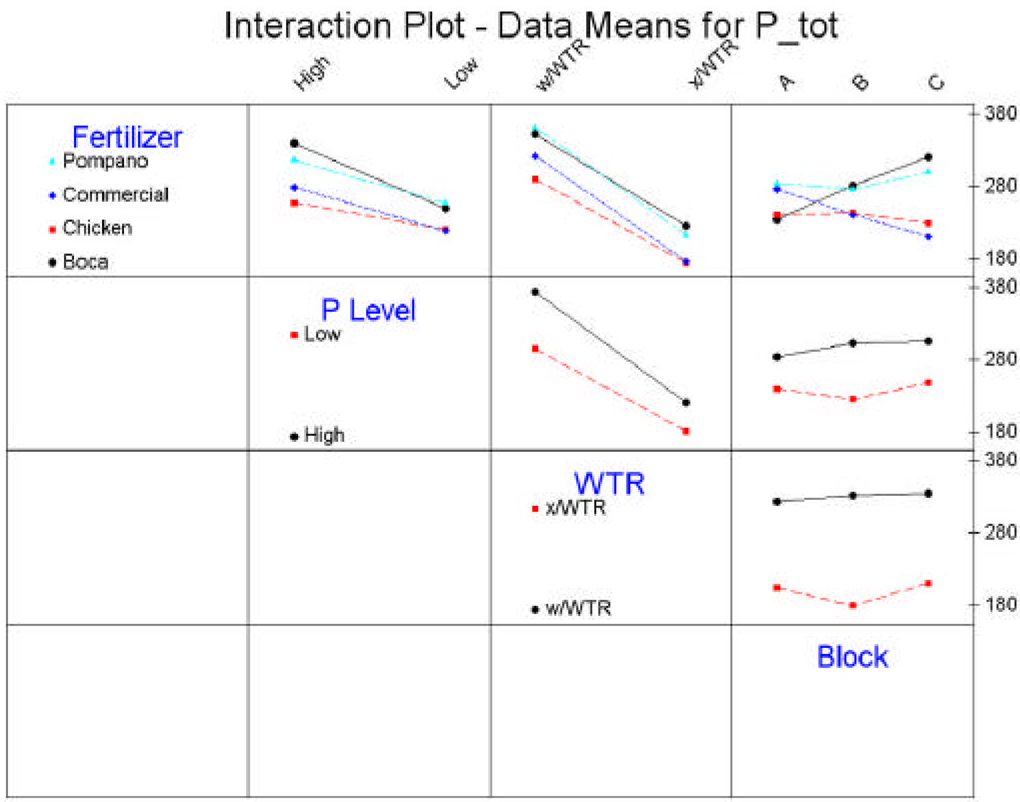

Figure 60. Interaction plot for soil P (mg/kg) in horizon A, as sampled on June 25, 2003. Reported P is Total P.

D. VEGETATION

Samples of the pasture grass on each plot were obtained on July 10 and October 17, 2003. The exact same locations were used for both sampling events. Two measurements were made of the samples: yield and tissue P concentration. From these two measurements, the total mass of P harvested from each plot was calculated. A summary of the statistical significance of the various treatment factors is provided in Table 19. These results are based on GLM analysis of the data shown in Table 20.

Results of the GLM analyses show that for none of the three parameters (yield, P concentration, or P mass) was fertilizer type a statistically significant factor. The amount of fertilizer applied to the plots (P-level low or high) was a significant factor for the tissue P concentration, but not for the yield. Thus, fertilizer amount was only a marginally significant factor for the P mass harvested. Only for the Pompano residual did yield clearly increase with increasing fertilizer amount. Results also suggest that increasing the amount of chicken manure actually decreased grass yield. The WTR (alum) amendment was a statistically significant factor for all three parameters. Phosphorus concentration decreased with the addition of WTR to the plots. As a result, total P harvested from the plots also decreased with the addition of WTR. Block was also significant for all parameters. Block C had lower yields than Block B, which were slightly lower that Block A. However, P concentrations in Block A were lower than in B while C varied. The mass of phosphorus per plot was greatest for Block B, followed by A and then C. Phosphorus concentration was consistently higher in the October samples compared to the July samples, but yields were higher in July.

Table 19. P values of grass analysis by GLM, as sampled on July 10 and October 17, 2003.

GLM	Responses	P_value				
Post-treatment		**Fert**	**P_level**	**WTR**	**Block**	**Dates**
	Forage yield	0.50	0.79	0.27	**0.00**	**0.00**
	P_conc	0.19	**0.00**	**0.00**	**0.01**	**0.00**
	P harvested	0.19	0.11	**0.00**	**0.01**	0.20

Table 20. Grass sampling results for July 10 and October 17, 2003.

ID	Forage Yield (kg/m2)		P conc in tissue (%)		Mass of P har. (kg/ha)	
	07/10/03	10/17/03	07/10/03	10/17/03	07/10/03	10/17/03
A1	0.437	0.103	0.12	0.22	5.20	2.22
A2	0.696	0.268	0.18	0.20	12.17	5.32
A3	0.395	0.184	0.12	0.24	4.74	4.45
A4	0.522	0.287	0.25	0.24	13.04	6.91
A5	0.319	0.239	0.18	0.21	5.84	5.11
A6	0.342	0.270	0.23	0.30	7.90	7.98
A7	0.347	0.211	0.17	0.21	5.83	4.42
A8	0.368	0.384	0.20	0.30	7.40	11.57
A9	0.265	0.286	0.17	0.23	4.60	6.44
A10	0.261	0.365	0.15	0.20	3.99	7.37
A11	0.400	0.262	0.15	0.21	6.12	5.51
A12	0.403	0.339	0.20	0.21	7.90	7.00
A13	0.358	0.341	0.18	0.25	6.34	8.60
A14	0.425	0.250	0.25	0.29	10.66	7.16
A15	0.349	0.305	0.23	0.23	8.12	7.15
A16	0.603	0.326	0.19	0.28	11.16	9.17
A17	0.366	0.328	0.20	0.23	7.25	7.70
B1	0.895	0.175	0.25	0.39	22.29	6.86
B2	0.391	0.241	0.25	0.23	9.66	5.46
B3	0.414	0.303	0.21	0.21	8.78	6.33
B4	0.366	0.192	0.18	0.28	6.66	5.39
B5	0.186	0.171	0.17	0.23	3.16	4.00
B6	0.381	0.148	0.17	0.17	6.32	2.52
B7	0.268	0.207	0.16	0.25	4.29	5.25
B8	0.374	0.271	0.16	0.24	6.01	6.54
B9	0.343	0.345	0.24	0.28	8.23	9.66
B10	0.460	0.276	0.25	0.28	11.58	7.63
B11	0.310	0.265	0.28	0.31	8.77	8.28
B12	0.408	0.392	0.37	0.33	15.14	12.77
B13	0.272	0.262	0.18	0.28	4.79	7.34
B14	0.403	0.296	0.21	0.30	8.49	8.93
B15	0.308	0.217	0.15	0.26	4.53	5.72
B16	0.343	0.319	0.29	0.28	9.90	8.76
B17	0.236	0.225	0.20	0.31	4.81	6.92
C1	0.227	0.129	0.16	0.22	3.71	2.80
C2	0.288	0.279	0.16	0.21	4.54	5.76
C3	0.166	0.297	0.13	0.18	2.14	5.24
C4	0.241	0.226	0.23	0.30	5.58	6.82
C5	0.360	0.342	0.25	0.28	8.89	9.74
C6	0.276	0.196	0.16	0.23	4.35	4.49
C7	0.243	0.165	0.19	0.25	4.61	4.07
C8	0.188	0.304	0.18	0.23	3.43	6.94
C9	0.228	0.249	0.18	0.27	4.17	6.64
C10	0.145	0.302	0.18	0.20	2.67	5.89
C11	0.245	0.274	0.25	0.23	6.17	6.41
C12	0.360	0.285	0.30	0.32	10.17	9.09
C13	0.201	0.186	0.17	0.21	3.46	3.81
C14	0.231	0.222	0.38	0.21	8.82	4.55
C15	0.376	0.225	0.27	0.23	10.01	5.20
C16	0.250	0.316	0.21	0.27	5.25	8.49
C17	0.209	0.233	0.18	0.27	3.76	6.32

Descriptive Statistics: Forage yield, P conc in tissue, Mass of P harvested

Variable	N	Mean	Median	TrMean	StDev	SE Mean
Forage y	96	0.3027	0.2865	0.2930	0.1138	0.0116
P conc i	96	0.22833	0.23000	0.22628	0.05528	0.00564
Mass of	96	6.890	6.375	6.671	3.044	0.311

Variable	Minimum	Maximum	Q1	Q3
Forage y	0.1030	0.8950	0.2288	0.3595
P conc i	0.12000	0.39000	0.18000	0.26750
Mass of	2.140	22.290	4.643	8.573

General Linear Model: Forage yield, P conc in tissue, Mass of P harvested versus Fertilizer, P Level, WTR, Block, Dates

Factor	Type	Levels	Values
Fertiliz	fixed	4	Boca Chicken Commercial Pompano
P Level	fixed	2	High Low
WTR	fixed	2	w/WTR x/WTR
Block	fixed	3	A B C
Dates	fixed	2	D_07_10_03 D_10_17_03

Analysis of Variance for Forage yield, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	0.02407	0.02428	0.00809	0.80	0.495
P Level	1	0.00071	0.00071	0.00071	0.07	0.791
WTR	1	0.01240	0.01240	0.01240	1.23	0.270
Block	2	0.13948	0.13948	0.06974	6.93	0.002
Dates	1	0.17862	0.17862	0.17862	17.75	0.000
Error	87	0.87549	0.87549	0.01006		
Total	95	1.23077				

Unusual Observations for Forage y

Obs	Forage y	Fit	SE Fit	Residual	St Resid
2	0.696000	0.386892	0.031357	0.309108	3.24R
17	0.895000	0.319471	0.030739	0.575529	6.03R

R denotes an observation with a large standardized residual.

Analysis of Variance for P conc in tissue, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	0.007542	0.008675	0.002892	1.60	0.194
P Level	1	0.016638	0.016638	0.016638	9.23	0.003
WTR	1	0.044204	0.044204	0.044204	24.51	0.000
Block	2	0.019115	0.019115	0.009557	5.30	0.007
Dates	1	0.045938	0.045938	0.045938	25.47	0.000
Error	87	0.156898	0.156898	0.001803		
Total	95	0.290333				

Unusual Observations for P conc i

Obs	P conc i	Fit	SE Fit	Residual	St Resid
28	0.370000	0.257736	0.013013	0.112264	2.78R
46	0.380000	0.226174	0.013013	0.153826	3.81R
65	0.390000	0.220805	0.013013	0.169195	4.19R

R denotes an observation with a large standardized residual.

Analysis of Variance for Mass of P harvested, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Fertiliz	3	35.277	36.835	12.278	1.61	0.193
P Level	1	19.515	19.515	19.515	2.56	0.113
WTR	1	80.997	80.997	80.997	10.63	0.002
Block	2	68.632	68.632	34.316	4.50	0.014
Dates	1	12.615	12.615	12.615	1.66	0.202
Error	87	662.986	662.986	7.621		
Total	95	880.022				

Unusual Observations for Mass of

Obs	Mass of	Fit	SE Fit	Residual	St Resid
4	13.0400	7.3452	0.8459	5.6948	2.17R
17	22.2900	5.7653	0.8459	16.5247	6.29R
28	15.1400	9.8776	0.8459	5.2624	2.00R

R denotes an observation with a large standardized residual.

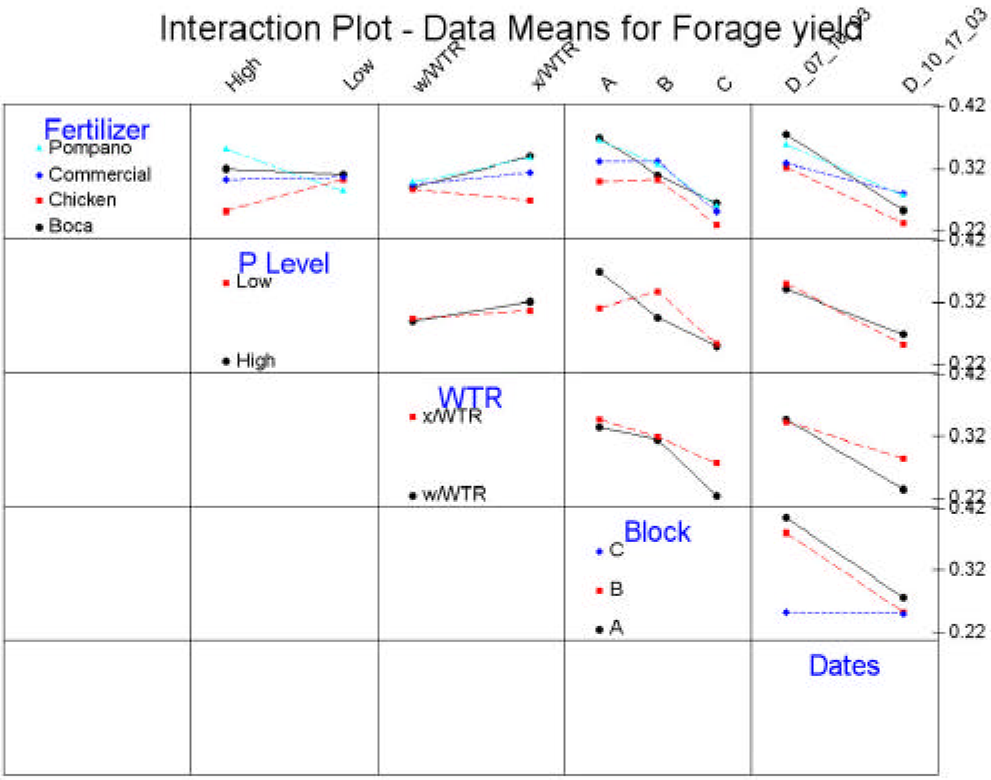

Figure 61. Interaction plot for forage yield (kg/m2) as sampled on July 10 and October 17, 2003.

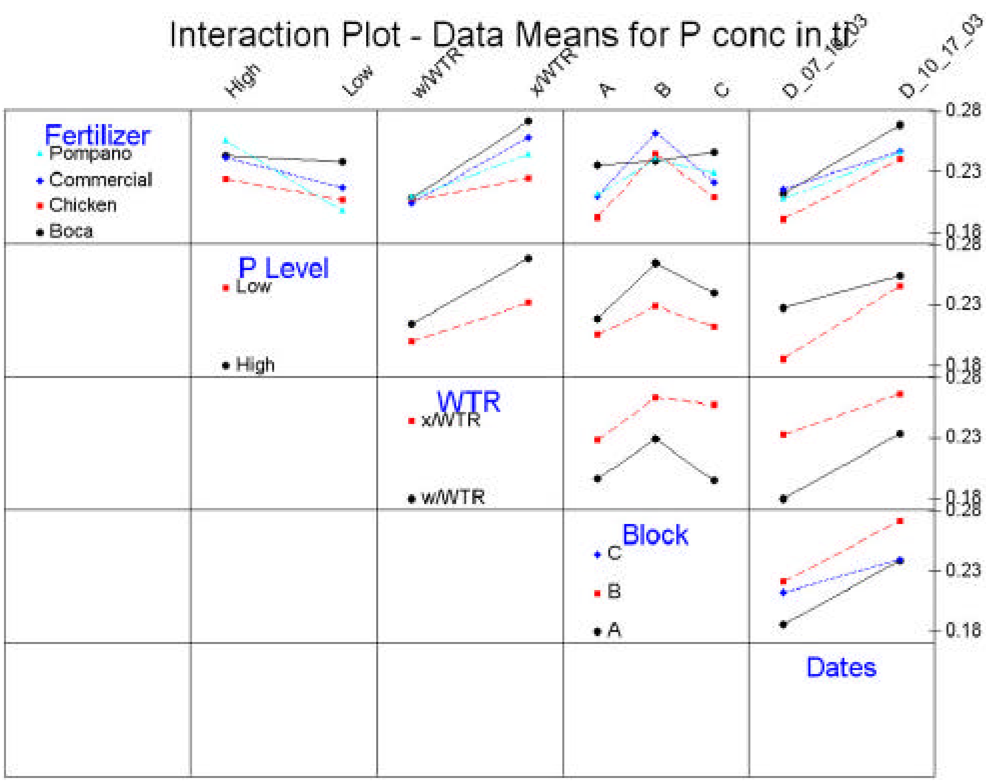

Figure 62. Interaction plot for P concentration in tissue (%) as sampled on July 10 and October 17, 2003.

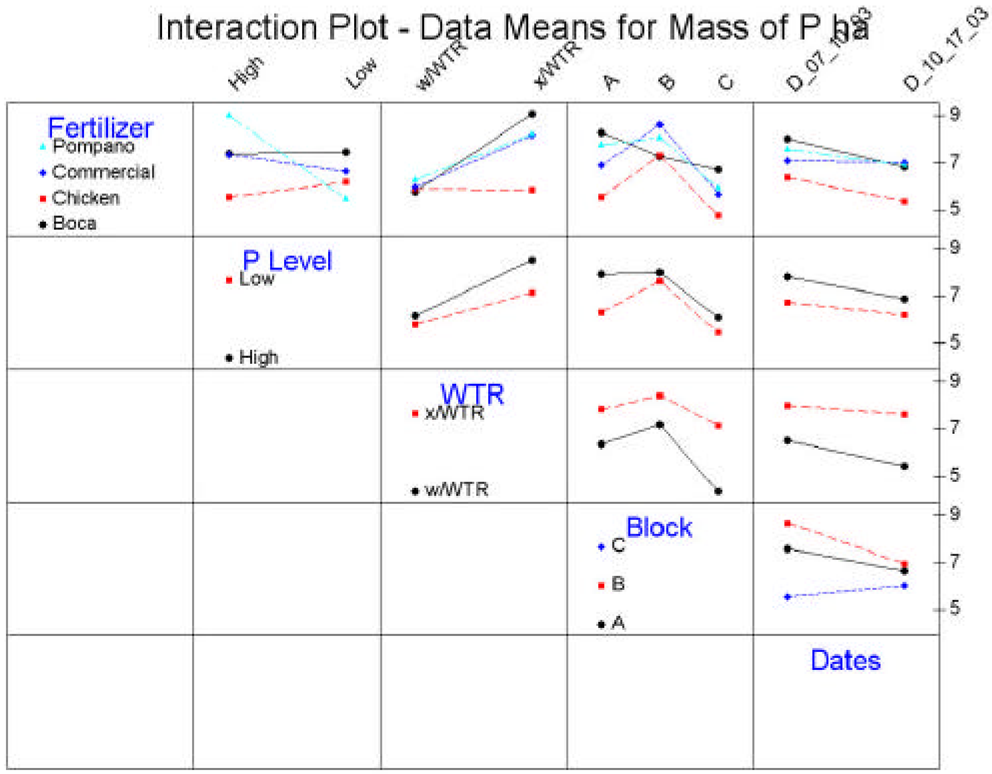

Figure 63. Interaction plot for mass of P harvested (kg/ha) as sampled on July 10 and October 17, 2003.

E. PROBLEMS & CORRECTIVE ACTIONS

Problems related to the data presented in this report (physical parameters, soils, and vegetation) include hay cutting and harvesting problems and instrument failures. The limited number of vegetation samples collected is the result of problems with farm operations. This problem needs to be solved before the next wet season. A better system for cutting, collecting and removing the grass from the plots needs to be implemented. Lack of proper grass harvesting also aggravated another farm operations problem, cattle entry to the plots. Lush vegetation encouraged cattle to breach the fence and repeatedly enter the plots. Another vegetation farm operations issue that need to be addressed is tropical soda apple control. Some physical parameter measurements were missed due to a faulty sensor probe. This probe has been replaced.

F. ACTIVITIES PLANNED FOR NEXT QUARTER

Activities planned for the period January – March of 2004 include the monthly ground water sampling, soil sample collection, expansion of the online database system to handle the physical parameters, soils, and vegetation data (in addition to the existing capabilities to process the water chemistry data). Work will continue to revise previous report based on comments of reviewer. Improvements in field and laboratory methods will be pursued to resolve problems with some of the phosphorus results.